THE UNIVERSITY OF ALBERTA

A SYSTEMATIC APPROACH TO THE DESIGN OF A UNIT OF INSTRUCTION FOR A SECONDARY SCHOOL GENERAL MATHEMATICS COURSE

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance a thesis entitled "A Systematic Approach to the Design of a Unit of Instruction for a Secondary School General Mathematics Course" submitted by Barry James Eshpeter in partial fulfillment of the requirements for the degree of Master of Education.

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ABSTRACT

Guidelines developed by mathematics teachers have suggested that an increased use of stimulus materials be made in order to make mathematics more interesting and relevant for low achieving students. While commercially produced materials are becoming more abundant they are often, for a variety of reasons, found to be unsuitable. In the preparation of this study a large number of materials and catalogs were examined in an attempt to discover what materials were available and suitable for an instructional unit on the topic of "measurement" for Mathematics 15 students. Portions of two video tapes were the only materials found that were considered to be of relevance to this project. Thus, there was a need to produce most of the materials at the local level. As local production is a rather complex matter, it was felt that it could best be handled within the context of a systematic approach. Thus the purpose of the project--to use a systematic approach to design, produce, field test, and evaluate prototype materials for a unit of instruction in the Mathematics 15 course.

Nine lessons were developed for the unit, each centered around one or more behavioural objectives. Each objective had been analyzed to determine which of eight types of learning (as identified by Gagné) were involved. Once the types of learning had been established, a highly structered lesson plan was devised for each lesson based upon the "conditions for learning" (as specified by Gagné). Each lesson involved a variety of media, and included two or three changes of

activity for the student during a class period.

Two Mathematics 15 classes from McNally Composite High School were involved in the study. An analysis of results showed that a majority of students from both classes had achieved some degree of success, post-test means being in excess of 70 per cent. An analysis of covariance was used to determine whether there was any significant difference between the means of the two classes since each had been taught by a different instructor. The analysis showed no significant difference.

Post-test scores were also compared with two pre-determined criterion levels. The first was a 70 per cent criterion level. Over 70 per cent of the students achieved a score of 70 per cent or better. The other criterion level was an individual one based on a student's best mark on either of two similar tests administered during that school term. Again, over 70 per cent of the students scored higher on the post-test than on either of the other two tests.

In order to determine areas in which either the post-test or classroom instruction had been weak, success rates on each test item were examined against a 70 per cent criterion level. The examination revealed that the criterion level was attained on fewer than 70 per cent of the test items.

To complete evaluation of the unit, a questionnaire was administered to the classes. Results from the questionnaire showed that the majority of students liked the slide-tape and video-tape presentations, the games, worksheets, and the student objective sheets. Most of the comments made about the unit were favourable.

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CHAPTER I

INTRODUCTION TO THE PROBLEM

1. INTRODUCTION

All teachers have encountered, at one time or another, the problems of irregular attendance, extended absenteeism, and student drop-outs. While these problems are found at many grade levels they are perhaps more common at the senior high school level. They have become more evident in recent years as high schools have increasingly adopted a more permissive "open-campus" philosophy with a liberal attitude towards attendance. The student who is bored by his class-work, or who is not experiencing much success, often opts not to attend.

The problems mentioned above are particularly acute in a so-called "non-matriculation" subject like Mathematics 15. The Mathematics 15 course, as presently constituted, was introduced into Alberta senior high schools in the fall of 1969. Designed for the low achiever, it emphasizes the application of simple mathematics to the everyday problems of the world of work and leisure. Mathematics 15 is structured around a textbook, General Mathematics: A Problem Solving Approach (Kinney, Ruble, and Brown, 1969). A great deal of flexibility is permitted a teacher in the choice of content, in time allocations, and in the choice of teaching method. However, there is some question as to whether teachers fully exploit the opportunity given to them by this type of flexible organization.

For two years this writer taught Mathematics 15 to a number of classes in an Edmonton senior high school. The teaching technique used was primarily expository with extensive use of the blackboard, and a relatively strict adherance to the textbook. In fact, the teaching technique varied little from techniques observed by this writer in other high school mathematics classes and aligned almost perfectly with Davis' description of the situation to be found in the typical elementary school mathematics class:

> . . . the usual (and nearly universal) mathematics class has children sitting in their seats, a teacher standing at the front of the room, no physical apparatus for the children to touch and play with, and a lesson involving merely talking, listening, reading, and writing (Davis, 1966, p.356).

That this approach is inadequate was made apparent through personal observation of student attendance, behaviour, attitude, and achievement. Davis (1966), and Johnson and Rising (1967), concur that a departure from the approach described above is necessary.

Mathematics 15 was chosen for this study for a number of reasons. First, the majority of Mathematics 15 students show little interest in mathematics. This lack of interest may stem from a number of factors which might include the uninteresting and unimaginative presentations of previous mathematics courses, and a past history of failure in the subject. Thus, there exists a challenge to design materials that will be of interest to the students and provide them with an opportunity to experience a greater degree of success. A second reason for choosing mathematics 15 was the fact that this writer had taught the course and was thus familiar with the type of student and with the course structure. This first hand experience resulted in a number of ideas for making the course more interesting. Then, there

was the flexibility provided by the nature of the course. Because there is no predetermined amount of material to be covered and because originality is encouraged, Mathematics 15 provides an excellent opportunity for experimentation with various materials and methods.

The Low Achieving Mathematics Student

According to the Curriculum Guide for Mathematics 15-25 (1969) the Mathematics 15-25 sequence has been designed for low achieving mathematics students. In fact, the vast majority of the students enrolled in Mathematics 15 are there because they received a mark of 50% or lower as their grade nine final mark. Thus, there is reason to believe that these students are indeed "low achievers" in mathematics, and it becomes important to study the characteristics of this group.

The low achiever as described by Johnson and Rising (1967) is a student who generally ranks below the thirtieth percentile in achievement. Rosenbloom (1965) characterizes a low achiever as a student having a low-average intellectual potential and who is generally one or more years below grade level in arithmetic and reading.

Rosenbloom's views are not completely supported by Hoffman (1968). She contends that low achievers in mathematics are frequently not slow learners in the sense of having low intellectual ability. In fact, many of these students have high IQ's and may have negative attitudes towards mathematics directly proportional to their intellectual ability.

Hoffman gives us further insight into the low achiever:

> Fear of mathematics and a distatste for any computation or for the kind of analytical thinking that typifies mathematics--these qualities characterize the slow learner in mathematics. This fear and distaste are born most frequently of some early fuzzy understanding or lack of understanding and are nurtured in

> succeeding years by the frustration of attempting to build new understandings on a nonexistent foundation.
>
> The student becomes, in consequence, a slow learner in mathematics or, more properly, a nonlearner beyond a certain level of competence. He finds all mathematics classes deadly dull; he sees little use for the subject. If he is a docile student, he endures quietly and with great boredom the mathematics course he is required to take; otherwise, he rebels and becomes a discipline problem as a protest against this total lack of understanding and interest (Hoffman, 1968, p.86).

Herriot (1967) contends that the term "slow learner" is often a misnomer because aptitude, reading, and achievement test scores are often not uniformly below average. Even uniformly low scores could be the result of a single factor--the inability to read. Other factors felt by Herriot to contribute to poor mathematical achievement include attitudes toward the discipline, the teacher, the school, the education itself.

Shoemaker and others (1968) working with low achievers in mathematics attribute them with the following characteristics:

> -A record of failure in mathematics.
> -Achievement scores three or four years below grade level in mathematics.
> -Reading and comprehension difficulties in many cases.
> -Quick conclusions formed without due consideration of facts.
> -Interest span very short--10 to 15 minutes at any activity.
> -High rate of absence.
> -Goals based on view of <u>immediate</u> future.
> -Antisocial behavior exhibited in classroom and school.
> -Inability to see practical use of mathematics (Hoffman, 1968, p.88).

<u>The Low Achiever as a Problem</u>

Today there seems to be a new concern for the low achiever. It is now recognized that lack of achievement and interest in school subjects could ultimately result in school dropouts and this at a time when lack of education is the greatest single cause of unemployment. In fact, according to Rosenbloom, who cites reports of the United States Department of Labor, "Mathematics and reading are the key subjects for

making low-ability children employable (Rosenbloom, 1965, p.25)."

Philips (1965) feels that training in mathematics gives a student a much broader choice of types of vocational training. He states that two thirds of the skilled and semiskilled job opportunities on today's labor market require an understanding of basic arithmetic, elementary algebra, and geometry.

Beckmann sees the problems of the low achiever as a crisis which can be expressed in a number of ways:

> in personal terms: eyes filled with fear or boredom, families frustrated or completely uninterested, a collapse of self-respect; in statistical terms: half of all ninth graders taking mathematics, or two million children in this one grade, enrolled in general mathematics classes; in economic terms: a nation handicapped by millions of mathematically illiterate adults . . . ; in social terms: thousands of families bound to generations of poverty by a chain of events . . . , in which scholastic failure is perhaps the link most accessible to efforts to help the poor break free; in political terms: cities disrupted by the rebellion of some of the same young men who slept through their classes a few years ago (Beckmann, 1969, p.443).

Suggestions for Dealing with the Low Achiever

Many of the people who have analyzed the characteristics of the low achiever and pointed out the consequences of not providing for them, have offered suggestions as to how to improve course offerings for this type of student.

Johnson and Rising (1967, p.191) see the problem of providing for the low achiever as five fold. First there is the teacher problem. The good teachers should be teaching the low achievers but they often do not want to, seeing the job as difficult and futile. Second, there is the curriculum problem. Attempts at concentrating on computational skills, taking a slower paced version of a college preparatory course

building a course around the mathematical needs of a citizen or consumer, or organizing one around a vocational area, have not proved satisfactory according to Johnson and Rising. They indicate that an imaginative new approach is needed for providing four to five years of sound mathematical content within the ability range of the student. Then there is the student problem resulting from lack of motivation. Motivation must be built in by providing appropriate content, materials, and methods of instruction. Fourth is the problem of parents unwilling to accept the placement of their child into the low achiever category. Finally, there is a materials problem. The slow learner needs a variety of experiences with concrete materials, many of which do not exist.

A number of the suggestions made by Johnson and Rising are encompassed in a series of guidelines established by the National Council of Teachers of Mathematics (Woodby, 1965). The Council has provided the following as a guide to teaching the low achiever:

1. Low achievers should be taught by able and well-trained teachers. Better teaching should enable the low achiever to learn much more mathematics than they ordinarily learn.

2. Modern educational technology should be exploited. The new media often add dimensions and insights for the low achiever not attainable from the chalkboard or printed page.

3. Classroom activities should be both purposeful and varied. Due to the relatively short attention span of the low achiever, a day's activity is best divided up into short segments of varied activities. Motivation should be captured through the use of games, puzzles, short cuts, and discovery exercises.

4. Particularly for the low achiever, the need for mathematics

comes from experiences in the physical world. Thus the real world can provide opportunities for a meaningful application of mathematics which in turn can make the real world more comprehensible to the child.

5. A laboratory setting is especially effective for the low achievers. Research evidence indicates that active experimentation and the handling of concrete objects precedes the abstraction stage of learning mathematical ideas. Many low achievers, even at the high school level, can benefit from a discovery-laboratory approach.

Availability of Resource Materials

At the heart of the suggestions made by Johnson and Rising and the guidelines offered by the National Council of Teachers of Mathematics is the need for more materials. Before you can provide students with a series of varied activities and before you can exploit educational technology, it is necessary to have a wide range of instructional materials.

One of the more obvious places to look for an inventory of instructional materials pertinent to a particular subject is a curriculum guide. The Curriculum Guide for Mathematics 15-25 (1969) has a rather extensive four page inventory of resources. However, three of the pages list print material. The fourth page, titled Instructional Materials, lists five games, a set of posters, and one kit. It makes no mention of audiovisual materials other than to encourage their use as an aid in the understanding of concepts.

The absence of a comprehensive listing of audiovisual materials in the curriculum guide is really not surprising. An examination of the many catalogs published by media producers reveals that there are materials available for this particular subject. However, many of the

materials which from the catalog would seem to be pertinent, upon examination, are often shown to be inadequate for teaching certain specified objectives. This point is born out by Geisz, Sachs, and Wendt, who state:

> Many of the films and filmstrips available cover very limited material and often in a manner not entirely compatible with the text being used, thus making such activity an uneconomical use of time (Geisz, Sachs, and Wendt, 1968, p.137).

In a situation like this there are two alternatives. The first is to tailor the teaching to the available material. If the materials are not completely suitable they can be treated as supplementary, or they can be edited with only the relevant portions of a filmstrip, film, or kit, extracted and introduced into the classroom. At best this is a superficial or low level of media utilization.

The other alternative is to produce the needed materials locally. Richard Hooper (1969) writes that local production has a number of advantages. In particular, he feels that it allows materials to be developed close to, and in response to, the real problems. Another reason for local production is advanced by Shea (1968). She feels that local production enables teachers to develop their own creative ideas in accordance with their specific approaches and students.

If a decision is made for local production the teacher immediately becomes involved in a rather complex problem. The problem is essentially one of deciding what materials to produce to best accomodate a variety of specific objectives. For example, would it be best to teach a particular concept through the use of a filmstrip or through the physical manipulation of materials? Will the students be

placed in small groups or allowed to proceed individually? If materials are to be designed how can this best be done to facilitate learning? Added to this are many other considerations--available personnel and production equipment, time and economic factors, and most important, the needs of the student.

<u>A Systematic Approach</u>

Henry Lehman writes that today when faced with a complex problem, someone invariably suggests a systems approach:

> The systems approach does not provide the ultimate answer by only adding water and shaking vigorously. The systems approach does provide an orderly process for developing a solution, a process which is structured to minimize prejudicial preconceived notions and maximizes the objectivity required to arrive at a scientifically correct answer (Lehman, 1969, p.144).

C. R. Carpenter (1960), one of the early advocates of a systems approach, claims that it provides a conceptual framework for consideration of functions and resources, including personnel and technical facilities, the kinds and amounts of resources, and a phased and ordered sequence of events leading to specified and operationally defined achievements. It also provides a way of checking on the performance of all parts of the system and makes provision for upgrading.

There is no single approach that can be called "the systems approach". Yet, an examination of various systems models reveals that most of them consider the same points and in roughly the same order. They usually include:

-A statement of a need or problem of a specific audience.

-A listing of objectives, usually stated in behavioural terms.

-A listing and analysis of alternative methods of presentation.

-Selection of method and materials from among the alternatives.

-Implementation of the program.

-Evaluation.

-Modification and re-implementation.

Although a systems approach would appear to be a desirable framework for designing instruction it was not feasible, in this study, to make use of a systems approach in the truest sense of the word. Implicit in a systems approach is a total commitment of human resources, as well as physical and technical facilities in the design, implementation, and evaluation of a course of study. This total commitment was, of course, not possible as it would have meant the reassignment of school personnel and facilities already commited to a diversity of other overriding goals. Thus, in this study, only a short portion of a course was designed and this was accomplished by one person in the design and production phases and by two in the implementation phase. A true systems approach is also of a cyclic nature with each implementation phase preceded by tryouts and followed by revisions before re-implementation. In this study, which constituted essentially a "preliminary development", the tryout phase was not followed by revisions and re-implementation, but only with recommendations on possible revisions and improvements.

Essentially, then, what has been used for this study is a modified systems approach. For the purposes of this study it will be called a systematic approach and will refer to an approach which parallels the systems approach but with the limitations recognized above.

2. STATEMENT OF THE PROBLEM

It has been suggested, in guidelines developed by mathematics teachers that an increased use of stimulus materials should be made in teaching low achieving mathematics students. They anticipate that an increased use of materials will make mathematics more relevant and interesting to students thereby reducing drop-outs. Unfortunately, there are few commercially produced materials available that are suitable to the endeavour. Thus, there is a need to design and produce materials at the local level. This is a rather complex problem and a systematic approach has been proposed as a method of dealing with it.

3. PURPOSE OF THE STUDY

Faced with the need of providing a greater variety of experiences for the low achiever in mathematics and with a shortage of appropriate stimulus materials with which to provide these experiences, the purpose of this study was to use a systematic approach to design, produce, field test, and evaluate, prototype materials for a unit of instruction in the Mathematics 15 course.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter is divided into two main parts. In the first part, an examination is made of mathematics programs of an innovative nature. In the second part, an attempt is made to examine projects that have been developed within a variety of disciplines but with a much more rigorous adherence to the principles of a systems approach as described in Chapter I.

1. MATHEMATICS PROGRAMS OF AN INNOVATIVE NATURE

An examination of books, periodicals, and documents pertaining to the teaching of mathematics reveals an increasing amount and variety of innovation. They point to a greater use of physical materials and to a broadening of the range of experiences available to a child in the mathematics classroom.

An example of a mathematics project that is trying to provide a more relevant form of instruction is one called the Wilmington Operational Mathematics Program (Rogler, 1967). It purports to have planned instruction, taking into consideration ways in which students learn, with attention to role playing, games, and programmed material. One of the aims of the program is to present real problems that involve student activity as well as laboratory work. This course is divided into a series of eleven units that cover such topics as the application of mathematics in carpentry, sports, and practical nursing.

The developers of the Wilmington Project, despite their avowed attention to the way students learn and their interest in games, laboratory experimentation, and "real" problem solving, came up with a rather unimaginative approach. The students were provided with a series of worksheets on each of the units. Although related to everyday activities, the worksheets did little more than comprise a different form of textbook. No findings are reported regarding student attitudes and achievement.

Project LAMP (Low Achiever Motivation Project) (Zimmerman, 1968) underway in the Des Moines, Iowa public schools, offers a similar approach. Here the emphasis is on a laboratory oriented approach. The topics covered are closely related to those offered by the Wilmington Project with an emphasis on real problems drawn from experiences and situations encountered in everyday life.

As with the Wilmington Project, Project LAMP concentrates on a single approach to a problem. In this case it is a laboratory approach. The use of audiovisual materials is advocated strictly for variety and not as an integral part of the teaching-learning process. Once again, there are no findings reported regarding student attitudes and achievement.

In Houston, Texas, a project was undertaken to aid the high school drop-out (Kneitz and Creswell, 1969). Sixty students, aged from sixteen to twenty two, were divided into three ability groups. They were given programmed instructional booklets, SRA computational skill kits, crossnumber kits, and other resources. Progressing at their own rates the students made an average gain of seven months achievement in two months.

This program used a wide variety of materials. Filmstrips, transparencies, and mathematical games were employed to promote and maintain interest and provide frequent changes of pace. Whether or not there was any systematic attempt at implementing the different phases of instruction was not evident from reading a description of the project.

Another study of a different nature was undertaken at a rural school in Wisconsin (Miller, 1966). Here the intent was to combine the principles of programmed learning with techniques of multi-media instruction in order to prepare automated-instructional units. Using a team approach which saw all of the mathematics staff involved in programming, a complete grade nine algebra course was devised. The course was completely programmed using slides and tapes primarily but with some use of motion pictures.

The Wisconsin study comes close to using a systems approach in the development of instruction. Topics were selected on the basis of presumed mathematical backgrounds. However, to insure that these presumptions were correct, pre-tests were administered to sample groups of students. These tests often resulted in modifications to the program. Scripts for the multi-media presentations were not prepared until behavioural objectives had been carefully analyzed and selection of content was not made until the analysis of objectives was completed. Also, the program underwent constant evaluation and was updated before each presentation.

The Wisconsin team produced two sets of materials. One set was highly directed, designed for low-achieving students. The other was aimed at high ability students. The criteria for selection of

content was that it " . . . should lend itself to the frequent and effective use of programmed instruction (Miller, 1966, p.11)." Daily presentations took the form of multi-media, programmed-instructional, group-paced lessons. Students were given an opportunity to interact with the presentation by responding to questions and solving problems. Evaluation of the study was confined to a comparison of the effects of the two sets of materials on various combinations of high and low ability students. No report was made regarding student attitudes towards the program.

In the fall of 1969, mathematics teachers at Hardisty Junior High in Edmonton, Alberta, installed an individualized program of their own devising. Later in the school year a team of graduate students and professors from the University of Alberta introduced another program into the school that came to be known as the "Hardisty Project."

The intent of the project was to provide a variable curriculum containing the following four aspects:

1. Varying time for each student on each learning task,
2. Varying learning tasks for individual students,
3. Varying modes of presentation or learning, and
4. Enrichment opportunities (Westrom, 1971, p.45).

As well as providing for individual differences in the amount and kind of content, provision was made to permit variations in the amount of time taken to cover the content. However, since the experimenters were working within the bounds of the traditional school system, they felt it necessary to set a minimum pace for each topic. Slow students were monitored to insure that they kept up. A maximum pace was also imposed by setting dates before which the next topic could not be started.

The developers of the Hardisty Project utilized many principles of a systems approach. They defined objectives and identified content. They produced materials, implemented instruction, evaluated it, and were continually refining the complete process. However, as in many other studies examined by this writer and reported earlier, the Hardisty experimenters concentrated on one particular medium (print), and one particular method (self-study), without due consideration to other experiences. This deficiency is pointed out in Westrom's report of the project. He reports that "the slow group experienced little success because of the large amount of reading and self-organization demanded of them (Westrom, 1971, p.88)." Westrom reports that the teachers involved in the study felt that a more manipulative approach would have been effective for the slow group.

2. SYSTEMATICALLY PLANNED COURSES

The I.P.I. (Individually Prescribed Instruction) program devised by the Learning Research and Development Center of the University of Pittsburgh is one mathematics program that has been developed in accordance with a systems approach. This program has been implemented in many countries, including Canada and the United States. In fact, until the Spring of 1971, the program was running in a number of Alberta schools including Forest Heights elementary school in Edmonton. The I.P.I. program at Forest Heights was dropped in the Spring of 1971 because of administrative problems and prohibitive costs. It was replaced by a program which incorporated many aspects of the I.P.I. structure and method but not its content.

There are six elements which characterize I.P.I.:

(1) detailed specifications of educational objectives;
(2) organization of methods and materials to attain these objectives;
(3) careful determination of each pupil's present competence in a given subject;
(4) individual daily evaluation and guidance of each pupil;
(5) provision for frequent monitoring of student performance, in order to inform both the pupil and the teacher of progress toward an objective;
(6) continual evaluation and strengthening of the curriculum and instructional procedures (Research for Better Schools, p.5, n.d.).

According to Ted Remple (1971) an administrator with the Edmonton Public School System who coordinated the program in the Forest Heights school, the I.P.I. program adhered to the aforementioned characteristics. Thus the I.P.I. program, as implemented at Forest Heights, represents a systems approach to the design of instruction. Although the program relied rather heavily on printed materials, recent experiments by the developers of the program are leading to an increased use of audiovisual materials in an attempt to relate to specific learning styles, and as alternate media.

Some systematic planning of courses has been done outside the mathematics field. Briggs (1967a) designed a day-long first aid course for an American company. In designing the course he first stated objectives in behavioural terms. He then determined which of eight types of learning, as identified by Gagné (1965), were involved in each objective. Using Gagné's conditions of learning as a guide (Gagné, 1965) he then developed media schedules and instructional sequences.

After much pre-testing of materials the first aid course was implemented. The course utilized motion pictures, programmed instruction, and live practice of procedures under an instructor's

guidance. Results showed that the poorest student in Briggs' course performed better than the best student in the old course.

Systematic procedures have been adopted in several cases by university teaching biologists in the design of instructional modules. A module, as defined by Murray, " . . . is a self-contained and independent unit of instruction with a primary focus on a few well-defined objectives (Murray, 1971, p.5)."

A module contains the following components:

1. Statement of Purpose
2. Desirable Prerequisite Skills
3. Instructional Objectives
4. Diagnostic Pre-Test
5. Implementers for the Module
6. The Modular Program
7. Related Experiences
8. Evaluative Post-Test
9. Assessment of the Module (Murray, 1971, p.5).

Postlethwait and Russell have stated a rationale for the development of the module or minicourse:

> One of the most important advantages of minicourses is the opportunity to develop, evaluate, and use a variety of instructional strategies to optimize instruction for students on a given topic. The approach can be carefully and deliberately sequenced, tried out with students, and revised until the maximum achievement is demonstrated by the most students (Postlethwait and Russell, 1971, p.26).

According to Postlethwait and Russell, one of the important characteristics of the minicourse is active student participation. The passive forms of listening and reading are replaced by active involvement with learning materials. The student conducts experiments, examines diagrams and photographs, views films and slides, handles biological objects and models, and responds to frequent questions put to him by audio tape and printed material. An important aspect of the module is that a student can use any or all of the media and materials

available. The selection of the most appropriate learning method is often left to the student.

Hurst and Postlethwait (1971) report that the Department of Biological Sciences at Purdue University introduced minicourses in 1969. Previous to that, the Department had pioneered in the development of an audio-tutorial approach to instruction (Postlethwait, Novak, and Murray, 1969). The development of minicourses from the multi-media, audio-tutorial approach required a minimum of modification but represented an attempt to move towards individual pacing and the idea of mastery. During the first year in which minicourses were offered, twenty per cent of the students received A grades.

A similar endeavor is underway at Columbia Junior College in Columbia, California. McDonald and Dodge (1971), report that a majority of students finishing their biology courses achieved an A grade. They attribute success in the program to a number of factors including precise statement of objectives, student paced learning, and the fact that students have had to learn how to study before they can complete much of the course.

Since 1967, faculty and graduate students at Indiana University have been involved in a series of institutes designed to orient them to a systematic approach to instruction. Working in teams consisting of a graduate student, who serves as an instructional developer and media specialist, and one or more instructors from a particular discipline, they have been attempting to come to grips with some of the "thorniest" problems in education today--large classes, insufficient faculty, poorly written texts, boredom of required courses, and others.

As with most other attempts at systematic instructional development, the institutes at Indiana University have been guided by a model.

The Indiana model is based on four activities considered necessary for teaching. They are:

1. Analyzing the learner;
2. Analyzing the learning;
3. Setting standards and measuring achievement;
4. Structuring the learning environment (Stowe, 1969, p.1).

Using this model and a flowchart developed from the model, each team developed an instructional product and most teams tested the product on students from their respective target audiences. The quantity of instruction developed by each team varied and ranged from nine hours to a complete semester's material.

An example of the type of work that was done is a unit developed by two professors of history and a media specialist on the topic of totalitarianism (Stowe, 1969). By the end of the unit, students were to be able to distinguish between states that could and could not, be considered totalitarian. A wide variety of media was utilized including playettes presented on videotape, film excerpts, speeches on audio tape, and overhead transparencies. One section of the final examination was devoted to the topic. Results indicated that the manner of presentation seemed to help the majority of the students in the middle grade range. As well, many of the students expressed interest and enthusiasm for the type of approach.

Another team composed of two faculty experts in Health and Safety, and a media specialist, developed a unit on the control of emergency bleeding. In this situation, the team was concerned, not only with the mechanical techniques required, but also in conditioning students to handle emotions that arise during an emergency of this nature. After careful examination of a wide range of media alternatives, the team finally produced a series of transparencies, motion picture film clips, and slides, as a way of introducing such topics as pressure

points and severe wounds. To enable students to cope with severe bleeding, the team designed and constructed a life-sized manikin with blood flowing at a controlled volume and pulse rate. With this model, a wide variety of wounds could be simulated, providing students with an excellent opportunity to practise in an atmosphere closely approximating a real life situation.

3. SUMMARY

In the review of the literature, there has been an attempt to point out that, while much innovation is on-going in mathematics, the tendency has been for developers to adopt a particular form of instruction such as programmed instruction, or the inquiry method, or the laboratory approach, and to exclude other methods or combinations of methods. Other developers advocate the use of a variety of materials as a means of stimulating interest and providing a diversity of experiences. However, there is no evidence to indicate that they have systematically examined their resources to determine the best combination for a particular learning event.

It should be pointed out that the situation in mathematics is by no means unique. An examination of the literature reveals a scarcity of materials dealing with the application of a systems approach to instructional design. However, there is some indication of an increasing awareness of, and experimentation with, a systems approach. In particular, the pioneering efforts of the Learning Research and Development Center at the University of Pittsburgh (Research for Better Schools, n.d.), Briggs (1967a), Postlethwait (1971) and his associates in biology, and Stowe (1969) at Indiana University, give evidence of this awareness.

CHAPTER III

DESIGN OF THE STUDY

The purpose of this study, as previously outlined in Chapter I, was to use a systematic approach in the design, production, field testing, and evaluation of prototype materials for a unit of instruction in the Mathematics 15 course.

This chapter begins with a discussion of the origin, and a description of, the systems model used for this study. From that point, the model is used as a basis for describing the design of materials and their field testing. The evaluation aspects of the model will be dealt with in a separate chapter.

1. A SYSTEMS MODEL

It is not difficult to find a model of a systems approach to educational planning. It is perhaps more difficult to decide which of the various models to use. Most textbooks written on the topic of audiovisual instruction devote at least part of a chapter to the consideration of a systems approach. In addition, the literature abounds with articles on various forms of a systems approach and its application in a variety of educational and non-educational settings.

The models are essentially the same. Variations are seen in the order of consideration of certain components and in the division of larger components of the model into more detailed and specific functions. All models seem to have a common concern with objectives and with an examination of methods, experiences, materials, equipment

and facilities, and the assignment of personnel. Another important aspect common to all is the evaluation stage which leads to modification and refinement of the process.

A model that seems particularly suited to this study because of its comprehensive nature is one that has been developed by Dr. J.J. LaFollette, assistant professor, Faculty of Education, University of Alberta. His model (LaFollette, 1970) brings together components from three major sources--Faris and Stowe, Briggs, and Project ARISTOTLE. The Faris and Stowe model (Faris, 1968), was originally devised to guide Indiana University faculty in improving undergraduate education. Briggs' model (Briggs, 1967b) was designed as a partial answer to the problem of assigning an instructional medium to each objective in the curriculum. The Project ARISTOTLE model (Lehman, 1968) resulted from a one year effort by a task force working specifically towards the derivation of a systems approach to educational problems.

The LaFollette model is broken down into four major stages--Problem, Design and Selection, Resources, Follow-Up--with each of these stages having further steps. This model (See Figure 1) will be used as a basis for outlining the design of the study.

2. PROBLEM

Review of the Problem

In Chapter I of this report, an attempt was made to outline the problem faced by low achieving mathematics students. A report by Philips (1965) to the National Council of Teachers of Mathematics was cited, which indicated a need for students to acquire an understanding of basic arithmetic, elementary algebra, and geometry.

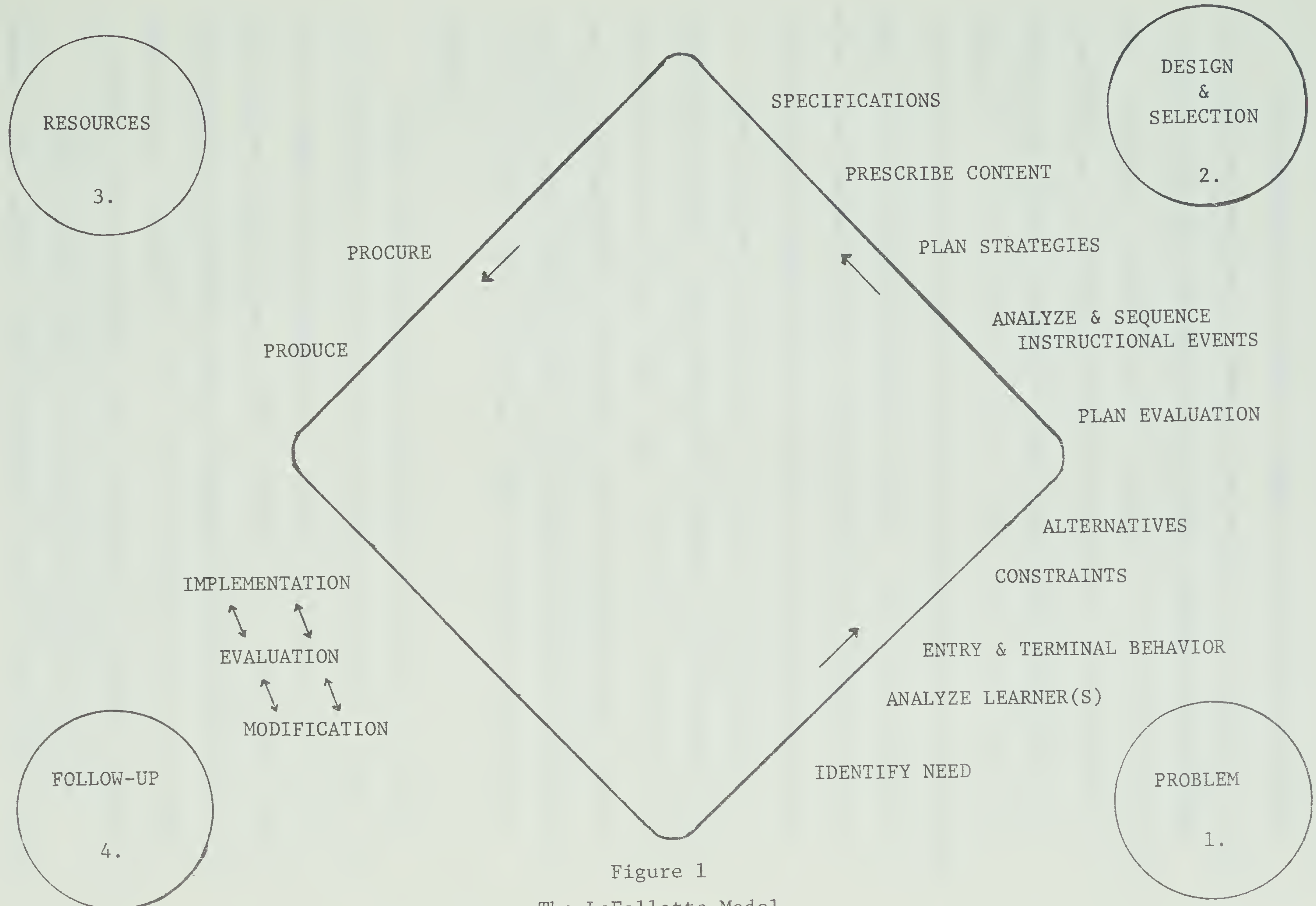

Figure 1
The LaFollette Model

The Mathematics 15 course attends, in some detail, to each of the topics mentioned above. However, as pointed out in Chapter I, there is reason to believe that there is not enough resource material available to teachers of Mathematics 15 to permit them to provide consistently stimulating and interesting classroom experiences. This absence of material was cited as a possible reason for student disinterest and absenteeism. It was further pointed out that, since there was little commercially produced material suitable to the endeavour, teachers would have to rely on materials produced "locally". With this necessity in mind, it was suggested that a systems approach be considered as one of the better ways of approaching the design of instructional materials.

For purposes of this study, a portion of the Mathematics 15 course was selected. The selection was limited to that portion of the course that had not been covered prior to the time at which this study could be implemented. As the study was not implemented until late in the school year, there were only a few chapters from the Mathematics 15 textbook (Kinney, Ruble, and Brown, 1969) that had not already been covered.

After some deliberation, measurement was chosen as the topic for development. It was selected for a number of reasons. First, one entire chapter of the Mathematics 15 textbook is devoted to the topic. This chapter (eight) takes a rather detailed look at the metric system and conversion from metric units to English units and vice versa. The fact that it is included in the book would indicate that it is likely considered to be a worthwhile topic by Provincial curriculum authorities.

A unit on this topic was considered worthwhile for other reasons. The need for accurate measuring, and the use of metric units,

is often encountered by a student in science courses. Often, these courses presume that a student has a good background in the metric system and, thus, provide little formal instruction in it. In actual fact, Mathematics 15 might be providing the first in-depth encounter a student has ever had with the system. In any event, it is likely to be filling in gaps in the student's knowledge and acting as a good review.

A recent publication by the Canadian Government entitled White Paper on Metric Conversion in Canada (1970), gives further justification for teaching the metric system. In the White Paper, the Government indicates that the adoption of the metric system in Canada is "inevitable". No specific date for this eventual adoption is mentioned but the Government expects that the change will be rapid in some areas and long and drawn out in others. The White Paper goes on to state:

> As a preparation for metric conversion, there would be an immediate need for greater emphasis on teaching the metric system and a consequent need for revision of textbooks (White Paper on Metric Conversion in Canada, 1970, p.13).

Analysis of the Audience

Thirty five students from two complete Mathematics 15 classes at McNally Composite High School in Edmonton, comprised the sample for this study. The students ranged in age from fifteen to eighteen and in grade placement from ten to twelve. They were assigned to their respective classes by a computer which handles individual time-tabling for the school.

Student Achievement Scores and Ability Rankings. In order to gain an insight into the capability of these students, a number of scores

were examined. The first was the students' mathematics mark on the Junior High School Achievement Battery. Another source of information was the verbal and quantitative SCAT (Cooperative School and College Ability Test) scores. The SCAT tests are reported by the Sixth Mental Measurements Yearbook (Buros, 1965) as being non-specific and indicative of a student's ability to achieve at school studies rather than of his actual achievement level. A third source of information was the cumulative percentile rankings based on the total of the verbal and quantitative SCAT Scores. It should be noted that all scores mentioned above were derived towards the end of the students' grade nine year. All scores are based on Provincial norms and thus indicate a student's relation to his peers throughout the province of Alberta. A summary of the four scores is contained in Table I.

Further insight into student capability was gained by comparing individual verbal and quantitative SCAT scores. In most cases the two scores varied and, while most variations were small (one or two stanines), some variations were extremely large. For example, one student scored 7 on the verbal and 1 on the quantitative. Another example, though not as extreme, saw a student score a 4 in the verbal section and a 7 in the quantitative.

In all, the students tended to fit the description of the low achiever offered by Hoffman (1968) who contends that low achievers in mathematics do not necessarily have low intellectual ability. An examination of the scores recorded by the students involved in this study would also tend to confirm the views of Herriot (1967) who says that the term "slow learner," when applied to this type of student, can be an inappropriate use of the word because aptitude, reading, and

TABLE I

ACHIEVEMENT SCORES AND ABILITY RANKINGS
OF STUDENTS PARTICIPATING IN THE STUDY

Standardized Tests	N	Mean	S.D.	Mediann	Mode	Range
SCAT Verbal (Stanine)	32	4.66	1.23	4.58	5	1-8
SCAT Quantitative (Stanine)	32	4.06	1.49	4.13	5	1-7
Grade Nine Math Achievement (Stanine)	31	4.29	1.13	4.32	4	2-6
Percentile Ranking	32	39.88	17.96	41.7	42	3-81

achievement test scores are often not uniformly below average.

Student response to an attitude questionnaire. A questionnaire administered one day prior to implementation of the program, attempted to ascertain, among other things, student attitudes towards mathematics, reasons for taking Mathematics 15, and future mathematical ambitions. The following is a brief summary of the information obtained from the questionnaire.

When asked whether they had enjoyed mathematics in elementary school, 63 per cent of the thirty five students who filled out the questionnaire, said that they had and 73 per cent said that they had done well in it. These results contrasted sharply with their attitude and achievement in junior high school. Only 17 per cent admitted to enjoying mathematics in junior high and the success rate was also much lower with the vast majority of students receiving a mark below 50 per cent as their final grade nine mark.

Forty one per cent of the students indicated that they were taking Mathematics 15 only because they were required to take a mathematics course if they wanted a high school diploma. Fifty five per cent indicated that they were taking Mathematics 15 as a means of raising their marks to enable them to get into the "academic" stream.

It should be noted that, even though 41 per cent of the students indicated that they were taking the class only because a mathematics course was required for a high school diploma, only 15 per cent of the students indicated no interest in taking further mathematics courses. Of the 85 per cent indicating further interest, approximately half desired to take Mathematics 25 which is a continuation of Mathematics

15. The other half showed a preference for more difficult mathematics classes that "articulate" with post-secondary educational courses.

The students were provided with an opportunity to comment on such things as why they were taking Mathematics 15, what they had liked or disliked about the course to that point, what they would do to make the course more interesting, and long range educational ambitions.

The majority of students liked something about the Mathematics 15 course although two students said they liked nothing about it. There was no unanimity on the likes or dislikes. Two students mentioned that they had liked the section on geometry and two more singled out a section on business mathematics as being particularly enjoyable. On the other hand, six people mentioned that the section on geometry was something they disliked and another three disliked the section on business mathematics.

A number of rather insightful suggestions were made regarding making Mathematics 15 more interesting. A number of students, presumably being held back by group pacing, suggested that the course be organized so that a student could proceed at his own rate. One person wanted special work in areas where he was weakest. Three other students felt that an increased use of audiovisual materials and realistic problem solving situations would make the class more interesting.

A high percentage of the students had apparently given some consideration to what they would be doing after high school. Most of them indicated that they would like to take courses of some kind with many of them specifying particular courses at either a university or technical school.

Entry and Terminal Behaviour

An examination of the chapter on measurement found in the Mathematics 15 textbook (Kinney, Ruble, and Brown, 1969) resulted in a partial list of aims and objectives for the unit. This list was added to, deleted from, and organized in terms of relative importance, after further consideration of the need for teaching measurement as discussed earlier in this chapter under the heading Review of the Problem. Each objective was written in behavioural terms and in accordance with the criteria established by Mager (1962) for the statement of objectives. Each objective indicated what the student would be doing when he was demonstrating proficiency, under what conditions this behaviour would occur, and the acceptable level of performance. A complete list of the aims and objectives of the unit can be found in Appendix B.

Once the unit objectives had been established, it was then possible to examine these objectives to determine what basic mathematical skills were prerequisite to their attainment. For example, one of the objectives required that a student be able to correctly convert a unit in the English system to its metric equivalent when given a table of conversions. Analysis of this objective indicated, among other things, that a student had to be able to successfully multiply numbers containing decimals. Other objectives were analyzed in like manner, which resulted in a listing of prerequisite mathematical skills.

Constraints

When faced with a problem in a teaching-learning situation,

constraints always exist which limit the number of feasible solutions. Sources of constraint include characteristics of the student population, economic considerations, school plant design, personnel, availability of equipment, administrative problems, and so on.

Prior to the implementation of the study, an attempt was made to identify all sources of constraint. The following is a listing of the constraints identified and attempts made at circumventing them.

Student Intelligence and Attitude. Student intelligence determined, to some extent, those topics that were included and those that were eliminated from the unit. Topics such as "relative error of measurement" and "significant figures," normally part of the unit on measurement, were eliminated. These topics had been found, by this writer and other Mathematics 15 teachers, to be very time consuming and not really worthwhile when considered in relation to even short term retention.

Intelligence was a consideration in determining the kinds of problems to be presented to the students. Complex verbal problems, abundant in the textbook, would not have been understood by the entire class and would have been successfully solved by only a handful of students. Therefore, it was decided to offer problems of this nature only as enrichment and on an optional basis.

It was felt that student attitude, as reflected by poor attendance and discipline problems, would also be a factor. To help build a positive attitude towards the unit it seemed necessary to pay more attention to motivation. This meant that some materials were presented simply for the sake of stimulating interest and not in the

light of their relation to specific behavioural objectives.

Economics. Financial considerations did not permit complete individualization of the program. The cost of providing slide tape sets, transparencies, and other materials, in sufficient quantities to permit individualization, would have been prohibitive. This meant that most of the materials were presented in large group situations.

Physical Facilities. The classroom available for the study was a small science room capable of seating thirty pupils. The room resembled a small theatre with four separate levels arranged in such a way as to enable students at the back of the class an unobstructed view of demonstrations at the front. This arrangement would have presented some difficulties for group or individual investigation of a laboratory nature. Thus, the only grouping that was attempted, was a pairing of the students to participate in a mathematics game.

The room was windowless and therefore presented no problems in darkening. Illumination for taking notes and writing answers to questions posed during slide-tape presentations was provided by a safety light at the front and a small incadescent bulb in a desk lamp at the back of the room.

Electrical outlets were checked and found plentiful both at the front and the back of the room.

Time. Mathematics 15 classes were scheduled for forty minute periods. Actual available time was closer to thirty five minutes as time had to be alloted for student movement to and from classes. This was a rather short period of time in which to accomplish anything of

significance and required careful planning of daily activities.

Equipment. To insure the availability of equipment for extended periods of time, it was necessary that a source other than the school be found. Arrangements were made with the University of Alberta to borrow an overhead projector with a wide angle lens, a slide projector, two audio tape recorders, a video tape recorder and a television monitor, for the duration of the study. A portable screen was the only piece of equipment used that belonged to the school.

Personnel. In order to gain a more complete idea as to the workability of the program, it was decided that the regular classroom teacher be given direct responsibility for one of the classes and that responsibility for a second class be assumed by the writer. It was considered necessary to involve the writer as an instructor for a number of reasons. One was to pick up flaws in the program that could be attributed to design. It was felt likely that the cooperating teacher, unacquainted with the way the program was designed to run, would not be able to distinguish difficulties encountered because of design flaws from those encountered due to unfamiliarity with the program. The involvement of two teachers was also related to the concept of reliability. It was felt that, if the two classes were taught by different teachers and yet reached approximately the same achievement levels, then the majority of the change in behaviour could probably be attributed to the program and not to the difference in teaching styles.

Administration. Due to a delay in the acquisition and editing

of a video-taped sequence it was not possible to introduce the study into the participating school until after the declared deadline for research projects. However, permission was obtained from the Principal of McNally Composite High School, Mr. W. Moysa, the Mathematics Department Head, Mr. C. Tymchuk, and from the cooperating teacher, Mr. D. Rosiewich, to introduce the study during the month of May. Because permission had been obtained from school officials, Dr. L. D. Stewart, Executive Secretary of the Cooperative Activities Program, Faculty of Education, University of Alberta, and Dr. E. A. Mansfield, Director of Educational Research, Edmonton Public School Board, granted their approval for the project.

Alternatives

Before proceeding with the design of instructional events and selection of appropriate materials, it was necessary to list alternative methods of presentation. Ideas were listed even if they seemed to violate constraints.

The following is an analysis of three modes of presentation considered for this study--large group, small group, and individual.

Large Group.

1) Teacher presentation - Teacher presentations can range from a pure expository approach with little student participation to a discovery approach that encourages considerable student-teacher interaction. Most teacher presentations combine elements of both approaches and will frequently be centered around a chalkboard.

2) Teacher combined with media - The teacher and various types of media combine in what can either be an expository or discovery

oriented approach. Media possibilities include--overhead transparencies, motion picture film, slide-tape sets, filmstrips, tapes and records, models and relia.

3) Media presentation - The bulk of the information in the lesson is presented by one medium or a combination of media. Options include--motion pictures, video tapes, slide-tape sets, filmstrips, audio tapes, and records. This type of presentation tends towards exposition but student involvement could be built in through the use of programmed learning techniques.

Small Group. Small group activity can take many forms. It can be centered around the solution of a problem, or the physical manipulation of materials in a laboratory setting. This activity can be closely guided by student worksheets or left relatively unstructured. Activity can take the form of discussions, game playing, or group study of films, filmstrips, and other media.

Individual. Again, a student can work with materials on specific problems using a worksheet or discovering on his own. He may learn through the use of a programmed text, at a computer terminal, or through the study of resource books. He can also make use of all forms of media at his disposal.

3. DESIGN AND SELECTION

Plan Evaluation

At this point it was necessary to design a pre-entry test to determine student readiness to enter the unit. The list of pre-requisite mathematical skills needed for the unit was examined and

used as a basis for selection of test items.

In fact, two roughly parallel tests were designed. The first was to be used to determine student knowledge of certain basic mathematical skills. Analysis of results on this test would reveal areas to be concentrated on in short "make-up" session to be offered to the entire class. The second test would reveal the success of the session and areas still in need of further clarification. Unfortunately, it was not possible to provide students who had done well on the first readiness test with alternate activities during the periods used for the "make-up" session and second test. There was also no provision for students who had not done well on either test, to do remedial work.

A decision was made to devise one test to serve as both a pre-test and as a criterion, or post-test. This test would be designed to measure achievement of the specified objectives of the unit. According to the sequence of the LaFollette model, the construction of the criterion test should have taken place at this time. In fact, a large number of test items were constructed at this time. However, the complete criterion test was not developed until just prior to the commencement of the unit. Although this violated the sequence of the model it was considered necessary for this study for a number of reasons. First, because the writer was unfamiliar with the students and their mathematical backgrounds, it was felt necessary to await results of the pre-entry tests in order to determine any shifts of emphasis that would be needed. In fact, the pre-entry tests showed a number of weaknesses that weren't remedied in the "make-up" session. This necessitated additional class time on topics that were considered prerequisite and meant that certain other objectives had to be dropped.

The writer also wished to include a number of questions which would require recall of information provided during class presentations and not included on the list of student objectives. These questions were not devised until all of the lesson plans were completed and all necessary materials had been prepared.

Analyze and Sequence Instructional Events

Under the heading Entry and Terminal Behaviour, objectives for the unit first came under scrutiny. Then, under the above heading, the objectives were analyzed to identify the types of learning involved. The basis for this analysis was work done by Gagné (1965) who has distinguished eight major kinds of mental processing which he calls learning. The eight kinds are called signal learning, S-R learning, chaining, verbal-associate learning, multiple discrimination, concept learning, principle learning, and problem solving. While a student may encounter any of these eight types of learning Briggs states:

> . . . the most frequently occuring types of learning in school subjects are concept learning, principle learning (including 'fact learning'), and problem solving (Briggs, 1967b, p.3).

Gagné, besides distinguishing the types of learning, has listed for each type of learning, " . . . a different set of conditions for its optimal occurence (Gagné, 1970, p.54)." As an example, he lists what would appear to him to be the most important events in the learning of a principle.

-Gaining and maintaining attention.

-Insuring recall of previously acquired knowledge.

-Guiding the learning with verbal or pictorial material that provide "cues" or "hints."

-Providing feedback to the learner on his accomplishments.

-Establishing conditions for remembering and transfer of learning.

-Assessing outcomes.

Briggs (1967b) has described a process by which the conditions of learning can be translated into a series of instructional events. He begins by listing unit objectives and then analyzing them to identify the types of learning involved. The next step is to design a "media program" which describes the sequence of events required for each particular form of learning. Finally, alternative methods of presentation are examined to determine which are most appropriate and relevant.

The process outlined by Briggs was followed very closely by this writer. For examples of how objectives were analyzed and "media programs" determined, see the lesson plans in Appendix E.

Plan Strategies

Each type of learning may have a series of media options. For example, in teaching a principle, there exist a number of options for gaining and maintaining interest. In fact the means of gaining interest might be superseded by another medium for maintaining it. Similar options exist for recalling information, presenting new material, providing feedback, and assessing outcomes. Thus at this point, it became necessary to list media options and examine factors which would aid in the selection of appropriate media.

Briggs suggests:

> It is at this point that one seeks ways to plan to use a single medium for the optimum length of time for the most appropriate set of objectives, without doing serious violence to the ways of providing the instructional events indicated as needed in the media schedules, and with minimum violation of cost and convenience considerations (Briggs, 1967b, p.48).

Briggs further suggests that a decision must be made at this point among the alternatives of group, or individual instruction, and teacher-conducted, or automated instruction.

Other considerations arise here. Campbell (Campbell in Briggs, 1967b, p.14) suggests that frequent changing of media may help prevent boredom and maintain interest and attention. This is particularly true for the slow learner. Johnson and Rising (1967, p.193) recommend the use of a variety of materials from day to day and even changes during a class period. They suggest that a class period could consist of a number of short sessions, none exceeding fifteen minutes, and including activities such as a game, a laboratory discovery period, a study period, and a short mental-computation drill.

Unfortunately, as pointed out by Briggs, there is no preset method for deciding which medium is most relevant for a given instance. However, it is possible to say:

> "Given this behavioral objective and this prerequisite repertoire of existing skills and knowledge, this concept may be taught by the following series of instructional events, for each of which any of several media could be applicable; . . . (Briggs, 1967b, p.15)."

Gagné (1970) asserts that the nature of the learning task itself may be the most important single criterion for the choice of a medium. Sometimes the choice of a medium may be obvious as in the case where a learner will be required to respond to real objects. In such a situation these objects should be used at some point in the instruction. However, this criterion often breaks down in a learning situation where one medium is as appropriate to the task as another.

Both Briggs and Gagné warn of the folly of expecting one medium to be capable of handling all aspects of instruction. As pointed out

by Gagné:

> . . . it seems likely that carefully designed combinations of media may be required to achieve the kind of instruction that is most effective, and which at the same time exploits the properties of media to fullest advantage (Gagné, 1970, p.62).

In review, the following points would seem to serve as partial guidelines in the selection of media.

-The nature of the learning task may be the most important single criterion.

-No one medium should be expected to do a complete job. Rather, a variety of media with different capabilities should be employed.

-Using a variety of media, aside from capitalizing on specific strengths of each medium, provides a means of reducing boredom and providing a stimulating classroom atmosphere.

-Ways should be sought to optimize the length of time a single medium can be employed.

-Cost and convenience of the ultimate media package should be considered.

Another area that necessarily received attention before the final selection of learning events was the area of research related to mathematics. For example, one of the questions that has been confronting educators is the role of manipulative activity within the classroom or in a laboratory setting. Bruner (1966) theorizes that individuals proceed through three "emphases" in development--manipulation and action, perceptual organization and imagery, and symbolic. By the time a student reaches high school he should be able to function at the symbolic level. However, Bruner warns that if this level fails an individual, there should be provision for interaction

with physical objects or images.

Robert B. Davis (1966) supports the increased use of physical materials in the classroom. His support is based on the cognitive psychology of Jean Piaget which contends that concept formation proceeds by stages and that concrete manipulation of materials is one of the stages. Davis also feels that the manipulation of materials leads away from authoritarianism in the classroom and towards the use of reality as the best source of information.

Game playing is a facet of activity learning that is receiving increased attention. Humphrey and Sullivan (1970) suggest that games provide a pleasurable, highly motivating way of personally involving students, and with providing a means for necessary repetition of basic facts. They go on to say:

> This concept of active games is in agreement with the basic educational principle that learning is always an individual matter but that it takes place most effectively in a social setting (Humphrey and Sullivan, 1970, p.11).

Discovery methods of instruction in mathematics have also received much attention. However, in a review of the literature published prior to 1969, Kieren (1969) revealed a theoretical conflict between those who supported and those who opposed discovery methods. He recommends that a coordinated research effort be mounted to examine specific questions related to both the discovery approach and manipulative learning. Kieren indicates that some very basic questions remain unanswered as yet; questions like: "For what purpose and for which students is the laboratory in mathematics an effective adjunct to mathematics classes (Kieren, 1969, p.518)?"

These considerations, along with the guidelines mentioned

previously, presented a reasonable, if somewhat inconclusive, basis for listing alternative means of presentation and for selecting from them.

The resulting lesson plans (See Appendix E) show the influence of the guidelines and of the mathematical considerations. For example, attempts were made to optimize the length of time a single medium was employed. Instead of jumping back and forth between two media, a single slide-tape set or a single video tape was employed to introduce a particular portion of the unit. At the same time, attempts were made to change the medium of instruction two or more times a period. In one instance, a class discussion lead to a slide-tape set which, in turn, lead to individual work on a worksheet.

Some activities were specifically designed to involve students with physical materials. In particular, the use of rulers was encouraged both as a means of comparing body measurements with historically established units based on the body and, as an aid in conversion between the English and Metric systems of measurement. Manipulation of materials was also encouraged in a conversion game which was designed in hopes of providing a pleasureable way of improving student's conversion skills.

It should be noted that financial constraints affected the mode of presentation and, to a lesser degree, the medium chosen. Had finances not been a consideration, there would likely have been more provision for individualized instruction. It would have required a large number of rather expensive duplicates of slide sets and transparencies. It is also possible that, given more financial freedom, motion picture film might have been more than a listed

alternative.

Specify Content

Each lesson, once begun with the statement of an objective, was then completely planned. Particular items of content were chosen only after the strategies had been fully developed. Attempts were made to select content on the basis of its usefulness to the learner in achieving the desired terminal behaviour.

Specifications

Commercially produced materials were examined to determine their suitability for inclusion in the study. Two mathematics programs, produced by the CBC and taped on school facilities during broadcast, were the only materials considered worthwhile. Specifications were prepared for introducing two twelve minute segments from these tapes into the lessons.

All other required materials had to be produced locally. Scripts were written for slide-tape presentations. Student worksheets and objective sheets were developed, and teacher guides were drawn up. Two conversion games, including the rules and details of the playing board, were designed.

Necessary materials were produced in accordance with a series of guidelines enumerated by Kemp (1968). His guidelines are based on summaries of audiovisual research completed by such people as Hoban and Van Ormer, Travers, and Gropper. Many of the guidelines apply only to motion picture and television production and therefore were not considered for this study. Other guidelines such as the need for repetition and summaries are well known and applicable to most types

of media.

In the production of the slide-tape sets a number of guidelines listed by Kemp (1968) were recognized. The following is a partial list of the guidelines, each one followed in parenthesis, by a brief description as to how it influenced the ultimate design.

-Overt (visible) response, practised by the learner during the film, results in increased knowledge. (Questions were asked during the slide-tape presentation. After each question the tape was stopped and students were required to respond to the question by writing on a specially prepared answer sheet.)

-Furnishing knowledge of results as part of the participation process also has positive effects upon learning. (After allowing sufficient time for the majority of students to respond, the tape was restarted. Immediate confirmation of the correct answer was provided, usually through both the audio and visual channels.)

-The simultaneous use of two senses (visual and auditory) are likely to be of value only when the rate of input of information is very slow. (Attempts were made to keep the amount of auditory information presented per visual, relatively low. Also, where interference was anticipated between the two senses, the visual was usually subordinated. In such cases a very low information visual or a blank slide was shown so that there would be little or no distraction from the auditory message.)

4. RESOURCES

With the exception of two video-tape sequences produced by the CBC for school telecasts, all material resources utilized in the study

were devised and produced by the investigator. Background information on the history of measurement and the origin of the metric system was obtained from the Ford Motor Company (1966) publication, Measuring Systems and Their History, the General Motors (1952) publication, Precision, a Measure of Progress, and from the Mathematics 15 textbook (Kinney, Ruble, and Brown, 1969).

5. FOLLOW-UP--IMPLEMENTATION, EVALUATION, AND MODIFICATION

Implementation

Implementation was begun with the administration of a pre-entry test to ascertain student readiness to enter the unit. A number of notable weaknesses were revealed including student inability to convert from fractions to decimals and vice versa. Due to a shortage of time, only one day was spent in trying to make up student deficiencies in the weak areas. Results on a second test that closely paralleled the first test indicated that one day was not enough. Though scores were generally better, in some cases students scored lower on the second test than on the first and showed evidence that they had only been confused by this one day "cram" session. It was thus decided that when areas were encountered requiring prerequisite skills time would be spent in reviewing them before discussing new material. Additional time spent in this manner added approximately one day to the length of the study.

After the readiness tests, a pre-test was administered to determine student knowledge of the material included in the unit. Two students each received a mark of 52 per cent which was the highest mark recorded on the test. The mean score of the two classes was

26.26 per cent.

Nine lessons were prepared for the unit, each planned so that it required one class period for completion. The lessons dealt with the following topics.

1. The history of measurement.
2. The limitations of measuring instruments.
3. "Rounding" measurements to varying degrees of accuracy.
4. Introduction to the metric system and it's terminology.
5. Conversion of linear measurements in English units to metric and vice versa.
6. Introduction to, and play of, miles-kilometers game.
7. Conversion of volume measurements in English units to metric and vice versa.
8. Introduction to, and play of, gallons-liters game.
9. Conversion of weight measurements in English units to metric and vice versa.

Only two lessons were not completed in the allotted thirty five minute time period. In both instances the reason was directly related to the fact that additional time had to be spent in developing heirarchical competencies before new work could be introduced.

Responsibility for the two classes was divided, the investigator being responsible for Class One which met during the first period in the morning, and the regular teacher responsible for Class Two which met during the second period. This arrangement was adhered to with the exception of two periods during which the cooperating teacher was absent and the writer accepted responsibility for both classes.

Due to a combination of circumstances, Class One, taught by

this writer, finished one complete period behind the other class. So that the two classes would write the post-test on the same day, and so that total instructional time for each class would be equal, Class Two was given a complete period for review purposes. Class One had only a small portion of a class period for review.

Evaluation and Modification

In the LaFollette model, Evaluation and Modification are grouped with Implementation under the general heading of Follow-Up. However, due to the extensive nature of the evaluation of this project and to the custom in thesis writing of devoting an entire chapter to a report of the findings, the evaluation report is included in a separate chapter (See Chapter IV). Suggested modifications are included in Chapter V, Conclusions and Implications.

CHAPTER IV

EVALUATION

It is generally agreed that evaluation is a fundamental part of curriculum development. Most often, however, evaluation takes the form of an achievement test which measures a particular pupil's achievement in comparison with other members in a group. Cronbach (1963) suggests that evaluation should go much deeper than this. He indicates that evaluation should be as broad as possible and should include such things as attitudes, career choices, general understandings, and aptitude for further learning.

Evaluation of the unit developed for this study took three major forms. Achievement was measured by a criterion test. The test developed as the criterion test was administered both as a pre-test and a post-test and was used to determine the extent to which students achieved the stated objectives of the unit. In addition to the criterion test, students were asked to fill in a questionnaire designed to determine their attitudes towards such things as the slide-tape and video-tape presentations, the games, the worksheets, and the objective sheets which indicated exactly what the students would be responsible for on the post-test. A final form of evaluation was supplied by the cooperating teacher who responded to a number of questions regarding the "workability" of the program.

1. THE CRITERION TEST

A criterion test, as defined by Lumsdaine, is a test

" . . . which reveals the extent to which a desired kind of competence, proficiency, capability, or desired behavioral tendency has been achieved (Lumsdaine, 1963, p.239)." As mentioned previously, the criterion test developed for this study was used both as a pre-test and as a post-test. The basic assumption underlying this usage was that gains in student knowledge are measureable and can be attributed to a treatment. However, Campbell and Stanley (1963) indicate that there are a number of extraneous variables that can jeopardize a conclusion which attributes gain only to the treatment. They mention such variables as history, maturation, the effects of testing, reactivity, and others.

There was reason to believe that most of the extraneous variables mentioned by Campbell and Stanley would have a negligible effect on the final outcome of the study. For example, the effects of history. Campbell and Stanley define history as "the specific events occuring between the first and second measurement in addition to the experimental variable (Campbell and Stanley, 1963, p.5)." It was felt that the effects of history could be largely ignored for the following reasons: the study was short--only two weeks; no homework was assigned so there was little liklihood that parents or peers contributed much in the way of outside learning; generally, the students were not of the type that would, on their own initiative, do outside reading or studying; no reference materials were available in the library even for those who exhibited sufficient interest to do further study.

Maturation effects, such as ageing, or being more bored, more tired, or hungrier, were also considered to have a negligible effect.

It was considered unlikely that two weeks of ageing would be a factor. And, while it is possible that some students were more bored, more tired, or hungrier while writing the post-test, it seems equally possible that there were students who were less tired, less hungry, and perhaps more interested, and that these effects would counterbalance.

Campbell and Stanley mention that a " . . . reactive effect can be expected whenever the testing process is in itself a stimulus to change rather than a passive record of behavior (Campbell and Stanley, 1963, p.9)." They mention as an example, the placing of an observer or a microphone into a normal classroom setting, an act which may change group interaction patterns. In this study, the test was a conventional one, requiring only that a student have a pencil to fill in blanks and to work out problems. The students did find one aspect of the pre-testing to be rather novel. They expressed some surprise and were rather dubious about being required to write a test on work that they had not yet covered.

Other aspects of the reactive effect mentioned by Campbell and Stanley include the artificiality of the experimental setting and the student's knowledge that they are participating in an experiment. They mention that the presence of "strange" teachers and the presentation of unusual treatments heighten this effect. These factors could definitely have effected this study. For a period of two weeks both classes encountered a series of experiences unlike anything experienced during that term in that course. They were unused to seeing slides and video-tapes, playing games, and having objective sheets and worksheets. In addition, each class experienced

a new teacher, Class One for the entire two weeks, and Class Two for two periods. These elements could have contributed to a gain from pre-test to post-test scores.

It should be mentioned, however, that care was taken to minimize reactive effects. To help avoid the creation of an artifical setting, the two classes were kept intact and they met at the usual times and in their usual classrooms. One of the classes was taught, except for two periods, by the regular teacher. The material studied during the two weeks was the material that the classes would normally have been studying. The classes weren't told that they were participating in an experiment but they were told that the marks they made on this unit would be counted towards their final mark in Mathematics 15.

The effect of testing is also mentioned by Campbell and Stanley. They cite evidence that tends to support the theory that writing a test for the second time or taking an alternate form of the test usually results in higher scores. Lumsdaine (1963) supports this idea but states that his experience has shown the effect to be rather slight. There is reason to believe that the effect, in this study, was also rather slight. After writing the test for the second time, the students in Class 1 were asked if they noticed anything familiar about it. There was no response from any member of the group until they were told that they had written the same test two weeks before. It seemed to be a complete surprise to all members of the class.

Descriptive Reporting of the Data

Ferguson (1966) refers to descriptive statistics as statistical

procedures used to describe the properties of a sample, or of a population where complete population data are available. For example, the mean IQ of a group would be a descriptive statistic because it describes a particular characteristic of that group. For purposes of this study, the phrase "descriptive reporting of data" will include descriptive statistics as well as evaluative comments from all participants.

Romberg calls descriptive evaluations " . . . the scientifically weakest but perhaps most practical evaluations . . . (Romberg, 1969, p.475)." However there is some precedence for this manner of reporting. One of the most innovative and well known mathematics projects, the Madison Project (Davis, 1965), relied on this type of reporting. Each school involved in the project used its usual procedures for assessing student growth and achievement. In addition, judgements of guidance counsellors concerning student attitudes, records on absenteeism, and the opinions of teachers concerning carry over into areas other than mathematics, were entered as evidence as to the efficiency of the project.

A study conducted by Shah (1969) is another example of a descriptive reporting of data. Children aged seven to eleven were taught a carefully developed set of geometry lessons. The students wrote an achievement test on which generally high scores were reported. The assumption was, that without the lessons, low scores could be expected.

Descriptive aspects of the data obtained in this study are reported in two separate parts of this chapter. Table II contains statistical data related to the criterion test. Student and teacher

TABLE II

DESCRIPTIVE DATA OBTAINED FROM AN ANALYSIS OF CRITERION TEST SCORES

	N	Pre-Test Mean	Post-Test Mean	Post-Test Median	Post Test Mode	Mean Gain from Pre to Post-Test	Range of Gain from Pre-Test to Post-Test
Class 1	20	26.8%	76.7%	79%	90%, 79%	47.8%	21%-60%
Class 2	15	26.0%	72.9%	70%	66%	47.3%	33%-71%
Total	35	26.4%	74.8%	79%	76%, 79% 85%, 88% 90% (3 each)	47.6%	21%-71%

evaluative data is reported later in the chapter.

Results reported in Table II indicate that students in both classes experienced some degree of success with means for each class in the 70's. The mean gain from pre-test to post-test was almost identical for the two classes. An analysis of the range of gain from pre to post-test indicates increases ranging from 21 per cent to 71 per cent.

One-Way Analysis of Covariance

With the exception of two periods, each class involved in the study was taught by only one teacher. In order to determine whether the two different teaching styles affected the final outcome, a one-way analysis of covariance was made. Ferguson states that an analysis of covariance is a statistical method that " . . . may be used to 'control' or 'adjust for' the effects of one or more uncontrolled variables . . . (Ferguson, 1966, p.326)." The two variables "controlled" for purposes of this analysis were student scores on the pre-test, and the SCAT quantitative scores.

Facilities of the Division of Education Research Services, University of Alberta, were employed for a computer analysis of the data. The program used was ANCV 1Ø. Due to a combination of circumstances including student absenteeism on the day on which the pre-test was administered, and the unavailability of SCAT quantitative scores for certain students, the analysis of covariance was made for an N of 25 students.

The results are summarized in tables III and IV. Table III shows the unadjusted and adjusted means or the means before and after

the consideration of the covariates. As can be observed, the adjusted post-test means for the two classes are very close.

TABLE III

UNADJUSTED AND ADJUSTED POST-TEST MEANS FOR THE TWO CLASSES

	N	Unadjusted Means	Adjusted Means
Class 1	16	74.5%	76.2%
Class 2	9	79.3%	76.3%

Table IV shows the results of an analysis of variance using the adjusted means for the two classes. The calculated probability of .983 tends to support the observation that the different teaching styles did not significantly effect the final outcome.

TABLE IV

SUMMARY TABLE FOR ONE-WAY ANALYSIS OF COVARIANCE

Source	DF	MS	ADJ F	P
GRP	1	.38	.49	.983
WTH	21	.78		

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[illegible]	[illegible]	[illegible]		[illegible]
		[illegible]		[illegible]

Establishing a Criterion Level

Table II shows that the majority of students in the study experienced some success. However, the question still arises as to the effectiveness of the program:

> Just absolute accomplishment presumably will not suffice; the question always arises of some kind of comparative evaluation that states how much a program will teach as compared to how much is taught by something else (Lumsdaine, 1963, p.247).

Lumsdaine goes on to suggest that the effectiveness of a program is usually measured against some baseline such as "conventional instruction," existing test norms, a similar program, or a "standard" program. He discards comparison with "conventional instruction" because there is no convenient way to define the term. Using existing test norms also presents difficulties because they are derived from standardized tests which are unlikely to have objectives commensurate with those of the experimental program. Comparison with a similar program is a possibility only if the two programs agree on the same set of objectives. The "standard" program is perhaps the most workable base of comparison as it connotes a comparative standard of performance which expresses the effectiveness of a program in terms of what is learned and the time taken to learn it. In this study, no baseline of comparison was used. Comparison with conventional classes was ruled out. Comparisons with existing test norms, similar programs, or standard programs, were not possible due to the unavailability of these alternatives.

If not through comparison, how can a course reasonably be assessed? "One notion that has gained considerable currency is that

a good program can get everyone up to 'mastery' in a subject (Lumsdaine, 1963, p.250)."

Although mastery for every individual may be unrealistic, Glaser and Cox state:

> There is a need to behaviorally specify minimum levels of achievement that describe the least amount of end-of-course competence the pupil is expected to attain, or that he needs in order to go on to the next course in a sequence (Glaser and Cox, 1968, p.547).

A problem is presented in trying to establish a minimum level of achievement (criterion level). Stewart (1969) states that proper procedures, when used within a "learning-systems concept," will result in 90 per cent of the students learning 90 per cent of the material. Some developers of programmed instruction have also adopted this level as a criterion level. Developers of other forms of instruction such as the developers of the biology minicourses also set criterion levels. They usually require " . . . 80% to 90% correct answers on written quizzes (Hurst and Postlethwait, 1971, p.30)." They don't require 100 per cent because human error typically accounts for one or more wrong answers even when students know the right answer.

<u>A 70 per cent - 70 per cent Citerion Level</u>. For the purposes of this study, the test scores were examined against two criterion levels. The first was arbitrarily established at a 70 per cent-70 per cent level. 70 per cent of the students should achieve 70 per cent correct answers. The criterion level was reduced from an 80 per cent or 90 per cent level to a 70 per cent level for a number of reasons. The 80 per cent and 90 per cent levels are established for programmed instruction or auto-instructional packages that are designed to

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accomodate individual learning styles and rates. This study did not make provision for a variety of learning styles nor for individual pacing. Thus, the lower criterion level.

Approximately 71 per cent of the 35 students writing the post-test exceeded the 70 per cent criterion level. The results are summarized in Table V.

TABLE V

NUMBER OF STUDENTS EXCEEDING
A CRITERION LEVEL OF 70 PER CENT

Group	N	No. exceeding 70%	% exceeding 70%
Class 1	20	17	85%
Class 2	15	8	53%
Total	35	25	71.4%

<u>Individual Criterion Levels</u>. Another method of evaluating student performance was chosen. It was based on the establishment of an individual criterion level for each student. The individual criterion level was arrived at by selecting a student's best mark from the results of two unit-end tests administered some weeks earlier in the school term. The two tests in question were judged, by the cooperating teacher who devised them, to be relatively equal in length,

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amount of material covered, and difficulty, to the criterion test. The student's best mark was compared to his mark on the criterion test. The results of this comparison, showing the number of students who exceeded their previous high mark, and the average percentage by which they exceeded it, are summarized in Table VI. The table indicates that 76.5 per cent of the students did better on the criterion test than they did on either of the two unit-end tests. It is recognized that this is a rather inadequate method of comparison as it is impossible to determine such things as the amount of material covered, and the difficulty of the material. However, the comparison does show that the majority of the students achieved as well, if not better, on this unit as on two other roughly similar units.

Analysis of Test Items

The first part of this chapter dealt with an examination of post-test scores as compared to a number of criterion levels. While this type of examination gives an indication as to the over-all effectiveness of a program, it does little to reveal areas in which the program is notably weak. Therefore, there was a need to evaluate the program from a different perspective. As Cronbach observes: "Analysis of performance or single items or types of problems is more informative than analysis of composite scores (Cronbach, 1963, p.683)." Thus, an analysis of student success on individual test items was undertaken.

As with the analysis of the post-test scores, and for the same reasons, a criterion level of 70% was established. Table VII shows the number of test items, and the question number of the test

TABLE VI

PERCENTAGE OF STUDENTS EXCEEDING A
CRITERION LEVEL ESTABLISHED BY TAKING THE BEST
OF TWO SCORES ON UNIT END TESTS

	N	Number of students exceeding previous high score	% of students exceeding previous high score	Mean gain	Number of students not exceeding previous high score	% of students not exceeding previous high score	Mean drop
Class 1	20	17	85%	20%	3	15%	9%
Class 2	14	9	64%	13%	5	36%	8%
Total	34	26	77%	16.5%	8	22%	8.5%

items, on which the criterion level was not attained. A copy of the criterion test can be found in Appendix D.

TABLE VII

ANALYSIS OF TEST ITEMS BASED ON
A 70 PER CENT CRITERION LEVEL

Group	Number of questions out of 26 on which criterion level was reached	Question numbers on which criterion level was not met
Class 1	17	2, 8, 12, 13, 14, 15, 19, 21, 26
Class 2	15	1, 2, 8, 12, 13, 14, 15, 19, 20, 21, 26

Table VIII gives further insight into student performance on test items. The table indicates how well each class performed on each post-test question. While the degree of success on the various test items varies markedly from class to class there is a great deal of concurrence when overall success and failure is considered. For example, when considering questions on which a 70 per cent level of success was achieved there are only two questions (#1, #20) which don't occur on both lists. Three questions (#1, #19, #26) show marked variations in performance from one class to the next. Variations range from 14 per cent on question #19 to 33 per cent on question #1. Probable causes for these variations and possible reasons for poor

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[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

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success rates on other test items are discussed subsequently.

TABLE VIII

CLASS PERFORMANCE ON
INDIVIDUAL POST-TEST ITEMS

Class One	Class Two	Percentage Success
4, 10	6, 10, 11, 16	90-100
6, 9, 11, 16, 17, 18, 22, 23	3, 4, 7, 9, 17, 18, 22, 25	80-89
1, 3, 5, 7, 20, 24, 25	5, 23, 24	70-79
8, 12, 14, 15, 19, 21	8, 12, 14, 20, 21	60-69
13	13, 15, 26	50-59
	19	40-49
2, 26	1	30-39
	2	20-29

The 70 per cent criterion level was reached by the total group on only 58 per cent of the questions. In order to determine possible reasons for this low success rate, each of the questions on which the criterion level was not attained was examined for possible causes. The

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[illegible]	[illegible]	[illegible]

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following is a summary of possible causes along with an indication as to which questions may have been influenced.

1. Absenteeism on the day the topic was presented is a likely cause for poor performance by Class 2 on question #1.

2. Questions #2 and #13 tested rather insignificant information that was not specified on the Student Objective Sheet.

3. Vaguely worded objectives could have contributed to poor success rates on questions #8 and #15.

4. Insufficient time to practice or develop new skills could have affected student performance on questions #12 and #19.

5. Insufficient review of pre-requisite skills was a likely contributor to the poor success rate on question #19.

6. Poor performance on questions #20, #21 and #26 was probably due to student inability to transfer acquired skills to slightly novel situations.

Test Validity

An attempt was made, during construction of the test, to ensure that test items measured what they were supposed to measure. As Briggs states: "A test is valid if it measures what it is supposed to measure--in the present context--if it measures the objective for which it is intended (Briggs, 1970, p.48)." Although initially it was thought that the test was highly valid, poor results on a number of test questions prompted a deeper investigation. The investigation uncovered the fact that poor performance on questions 2, 8, 13, 15, 20, 21, and 26 could be traced, at least in part, to discrepancies between behavioural objectives and the test items used to measure them.

The reasons why these test items were not particularly accurate measures of certain objectives was discussed in some detail under the heading, Analysis of Test Items.

Test Reliability

The criterion test was not designed in a manner conducive to an easy statistical computation of its reliability. Test questions were unequally weighted, making difficult such techniques as correlating scores on odd-numbered items with those on even-numbered items. Reliability testing was also constrained by the lack of time which necessitated a relatively short test and only one period in which to administer it.

Instead, a rather subjective type of reliability judgement was attempted. Again, guidance was obtained from Briggs who, when referring to reliability states:

> When constructing a test that will be valid for a given objective it is designed to measure, it is also important to test the student thoroughly enough to be satisfied that resulting scores accurately reflect his true ability to perform on the objective (Briggs, 1970, p.58).

In an attempt to arrive at some measure of reliability for the criterion test, each behavioural objective was examined against the kind and number of test questions designed to measure it. The following is a listing of the objectives as numbered on the student objective sheets (See Appendix C for the student objective sheets). Each objective is analyzed in terms of the kind and number of test questions included on the criterion test used to assess it (See Appendix D for the criterion test). It should be noted that all judgements made on the reliability and validity of test items were

made by the investigator.

Objectives 1 and 2 - One question was considered sufficient for each objective.

Objective 3 - One question with six parts was used for this objective. It was judged to be a reliable indicator of the desired performance.

Objective 4 - Two questions, one with three parts, were used for this objective. They were judged reliable.

Objective 5 - The question itself (#8) was judged to be a good indicator of student ability to perform the desired behaviour. However, it is possible that the students did not understand the objective.

Objective 6 - Questions #9, #16 and #18 were all used to assess various parts of the objective. Each question contained four parts. The questions were judged reliable because they aligned pricisely with the objective.

Objective 7 - Seven questions were used to assess this objective. Four of them (#'s 22, 23, 24, 25) were judged to be reliable and indicative of the students ability to perform conversions. Questions #20, #21 and #26 were not considered reliable indicators of the student's ability to convert measures from one system to another. Success on these questions would likely indicate that students could perform conversions with little difficulty. However, failure on these items did not necessarily mean that a student could not perform the conversions.

Objective 8 - Only one question (#15) was used to test this objective. It was judged not to be reliable as it sampled too limited a range of the possible questions. However, objective #8 encompassed

little new information and it was not thought important enough to give more weight to.

Objective 9 - Two questions (#12, #17), one with five parts and the other with three, were used to assess this objective. The questions were judged reliable.

Objective 10 - Two questions were used and judged to be reliable.

In summary, the majority of test items were judged to be of the type that would " . . . test the student thoroughly enough to be satisfied that resulting scores accurately reflect his true ability to perform on the objective (Briggs, 1970, p.58)." The four exceptions were questions #15, #20, #21 and #26. Question #15 sampled too small a range from the universe of possible questions. Questions #20, #21 and #26 did not totally reflect student ability to convert various measures.

2. EVALUATION OF STUDENT QUESTIONNAIRES

The second main form of evaluation of the unit, in addition to analysis of post-test scores, was a student questionnaire (See Appendix G). This questionnaire was administered three days after writing the post-test and before the post-test results were released. It was hoped that, through the questionnaire, student attitudes towards the slide-tape and video-tape presentations, games, worksheets, and the unit in general, could be ascertained.

On questions 3-6 of the questionnaire, students were asked to indicate which of four statements best indicated their attitude towards a particular aspect of the program. They could respond by

checking one of the following statements: I didn't like them at all; I didn't like them much; I liked them; I liked them very much. For purposes of evaluation, check marks beside the first two statements were taken to indicate dislike; check marks beside the last two statements were taken to indicate a positive attitude. In order to get a more comprehensive look at why students either liked or disliked something, opportunity was provided at the end of each question for the student to comment. Opportunity was also provided on page two of the questionnaire for students to comment on other things they liked or disliked about the unit and the way it was taught, how they would improve the unit, and how they would improve the Mathematics 15 course.

Student Attitude Towards the Video-Tape and Slide-Tape Presentations

Approximately 82 per cent of the students indicated a positive attitude towards the slide-tape and video-tape presentations. A recurring comment was that the presentations made things more interesting and easier to remember. As one student put it: "I have remembered more than teacher verses student." Another student commented that she didn't like the presentations too much because they moved too quickly and she couldn't understand them. Two students indicated some disapproval of the video-tapes. One fellow stated that "on the video tapes the guys seemed sorta crazy." He was referring to the two hosts of the program who tended to "ham" things up a bit. Another student commented: "I thought those video-tapes were pretty corny designed for Grade 2's or so. But I enjoyed watching them. However, I didn't remember anything on them."

Student Attitude Towards the Games

85 per cent of the students indicated a favourable attitude towards the games. Comments indicated that the games had been good practice in learning how to convert. As one student stated: "All I can say is that I know now how to convert." Another didn't like them much but considered them good practice. One student who liked the games, though not completely, said: "The reason I didn't like them a little bit is that I never won."

Student Attitude Towards the Worksheets

Once again, overall student attitude was favourable with 85 per cent of the students indicating a liking for the worksheets. One student commented: "When I did the sheets it wasn't like work (which I hate) but more of a fun assignment." Another student felt that the worksheets helped a great deal but would have liked more time to do them. "Found them terrific references, and gave me practice on what I needed," is a statement that typifies the other comments made concerning the worksheets.

Student Attitude Towards the Student Objective Sheets

Here again, an 85 per cent favourable attitude was recorded. Students found the objective sheet helpful because, as one person put it, "They told us what we were supposed to know." Another student stated that they were very helpful and expressed the wish that more teachers would use that method.

Calculation of Chi Square

In order to obtain additional information concerning student

responses to questions 3-6 on the questionnaire, a calculation of Chi Square was made for each question. For purposes of calculation it was assumed that expected responses would be equally split between those who liked, and those who disliked the treatment.

The results of the Chi Square calculations are summarized in tables IX and X. Table IX is a summary of student reaction to the slide-tape and video-tape presentations. A Chi Square of 13.36 was calculated which, with one degree of freedom, represents significance at the .001 level.

TABLE IX

CALCULATION OF CHI SQUARE FOR
STUDENT ATTITUDE TOWARDS SLIDE-TAPE AND
VIDEO-TAPE PRESENTATIONS

Response	0	E	$\frac{(0 - E)^2}{E}$
Like	27	16.5	6.68
Dislike	6	16.5	6.68
Total	33	33	Chi Square 13.36

With 1 df. there is significance at .001 level

Table X shows a summary of student reaction to the games. A Chi Square of 16.02 was calculated which, with one degree of freedom, represents significance at the .001 level.

TABLE X

CALCULATION OF CHI SQUARE FOR
STUDENT ATTITUDE TOWARDS GAMES

Response	0	E	$\frac{(0 - E)^2}{E}$
Like	28	16.5	8.01
Dislike	5	16.5	8.01
Total	33	33	Chi Square 16.02

With 1 df. there is significance at .001 level.

Summary tables of student reactions to the worksheets and the objective sheets have been omitted because the response to those questions was identical to the response obtained to the question concerning the games. In all cases there was significance at the .001 level. These results confirm the impression that the majority of students were favourably disposed towards the materials developed for the unit.

<u>Other Comments Concerning the Unit and Mathematics 15</u>

There was no consensus as to what students seemed to enjoy most. Some enjoyed the history of measurement; others commented on the slide-tape sets and classroom demonstrations. Some said they

liked everything. The one recurring comment was that it was not a hard unit.

The students weren't unanimous in their dislikes either. One person didn't like conversion, another didn't like the test. One student felt there wasn't enough time while two others felt the unit was too drawn out.

When asked how they would make the unit more interesting, a number of students said they couldn't think of anything. Somebody said, "quit playing games," while another said "have more of them games." One person would like to see crossword puzzles included in the unit. Another would favour the idea of using worksheets for everything. Two students would like to make the unit a little harder.

A large number of students indicated that they would like to see the entire Mathematics 15 course taught in the manner of this unit. They indicated a desire to see more slide-tape sets, play more games, and see more films or video-tapes because they made mathematics more interesting. One person said that he would like to see "unipacs" brought into Mathematics 15. Another wanted more involvement between the teacher and students so that he would be "happier to come." It seems, however, that for some students, "mathematics is still mathematics and there is really not much you can do."

3. TEACHER EVALUATION

It was considered important to include in the evaluation of the project, the comments of the cooperating teacher, Mr. Dmetro Rosiewich. Mr. Rosiewich is the head of the Physical Education Department at McNally Composite High School and during the course of

the study was very busy with his teaching assignments and preparation of the school's track and field team. This left him little time to become involved in the preparation of materials or even in pre-viewing the available materials. During the first week of the study Mr. Rosiewich "sat in" on the class being taught by this writer. This, combined with a tightly scripted lesson plan, served as his lesson preparation. During the second week, however, his class moved ahead by one lesson and, thus, his only guide was a teacher's guide that had been prepared. His comments on the project are included in Appendix A.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

1. SUMMARY OF THE STUDY

Guidelines developed by mathematics teachers have suggested that an increased use of stimulus materials should be made in order to make mathematics more interesting and relevant for low achieving students. While commercially produced stimulus materials are becoming more abundant, these materials, for a variety of reasons, are often found to be unsuitable. In the preparation of this study, a large number of media catalogs were examined in an attempt to discover what materials were available and suitable for an instructional unit on the topic of "measurement" for Mathematics 15 students. In addition, numerous filmstrips, transparencies, and multi-media kits, as well as three video tapes, were examined. Portions of two video tapes were the only materials considered to be of relevance to this project. Thus, there was a need to produce most of the materials at the local level. As local production is a rather complex matter, it was felt that it could best be handled within the context of a systematic approach.

Before the materials developed on the topic of "measurement" were introduced into McNally Composite High School, a readiness test was administered to the two Mathematics 15 classes participating in the study. This test was used to measure the extent to which students had mastered mathematical concepts considered to be prerequisite to topics that would be introduced during the course of the study.

Results on this test revealed a number of areas in which the students were notably weak. One class period was devoted to a review of those weak areas. Results on a second test, roughly parallel to the first, indicated that the review time had not been sufficient and that further time would have to be spent on prerequisite heirarchical competencies. Additional time spent in this manner added one complete day to the length of the study.

In addition to the readiness tests, a pre-test was administered to the students. The pre-test was used to determine the extent of student knowledge on the material to be covered during the study. The mean score of the two classes on this achievement test, was 26 per cent. A detailed examination of the results showed that there were no areas of study that could be omitted from the unit.

Nine lessons were developed for the unit, each centered around one or more behavioural objectives. Each objective had been analyzed to determine which of eight types of learning, as identified by Gagné (1965), were involved. Once the types of learning had been established, a highly structured lesson plan was devised for each lesson based upon the "conditions for learning" (Gagné, 1965). Each lesson involved a variety of media, and included two or three changes of activity for the student during a class period.

The students were provided with a list of behavioural objectives, which indicated exactly what they would be responsible for at the end of the unit. Each day they were referred to the particular objectives that would be considered during that class period. The objectives themselves, were often cross-referenced to particular problems that were included on student worksheets. The worksheets were the primary

means used in this study to gain degrees of individualization. The other materials, due mainly to constraints of an economic nature, had to be presented in large group sessions. Because of this, group pacing had to be maintained throughout the duration of the study.

2. SUMMARY OF THE FINDINGS

It would appear, on the basis of the evaluation that was done, that the unit was reasonably successful both in terms of the amount of learning that resulted, and in the students' attitudes towards the unit. For the first time during the school year, and perhaps in many years, a number of students were achieving a high degree of success in mathematics. This is evidenced in part, by the mean scores for Classes 1 and 2 which were 76.7 per cent and 72.9 per cent respectively, and by the correspondingly high medians and modes. An analysis of covariance was used to determine whether there was any significant difference between the achievement of the two groups involved in the study since they had been taught by different teachers. The analysis showed no significant differences.

As this was not a comparative study, other methods of reporting the data, in addition to a descriptive method, were considered necessary. One method saw the establishment of a 70 per cent-70 per cent criterion level. This standard was reduced from the 80 per cent and 90 per cent levels usually established by developers of programmed and individualized instruction. This was done because the study was not designed to accomodate individual differences. In comparing students to the 70 per cent-70 per cent criterion level, it was found that 71.4 per cent of the students scored at, or above 70 per cent on

the criterion test.

Another method for evaluating the results saw the establishment of individual criterion levels based on a student's best mark on two similar tests administered during that school term. The two tests in question were judged, by the teacher who devised them, to be roughly equivalent in length, amount of material covered, and difficulty, to the criterion test. 76.5 per cent of the students scored higher on the criterion test than on either of the two similar tests. The mean percentage increase over the best previous score was 17.5 per cent.

In order to determine particular areas in which either the test or the classroom instruction had been weak, individual test items were examined. As with student scores, a 70 per cent criterion level was established. Of the twenty six test items, only fifteen reached the 70 per cent criterion level. Each of the eleven questions on which the criterion level was not attained was analyzed in order to ascertain possible reasons for the difficulty. Likely sources of difficulty were thought to include questions which tested insignificant material, insufficient time spent on prerequisite skills, and test items that did not adequately test stated objectives.

To round out evaluation of the unit, a questionnaire was administered to the classes. Results from the questionnaire showed that approximately 85 per cent of the students liked the slide-tape and video-tape presentations, the games, worksheets, and the Student Objective Sheets. The majority of the comments made about the unit were favourable.

3. CONCLUSIONS

1. Students performed as well, or better, on this unit as they had on other units in the Mathematics 15 course. As it was not possible to accurately compare the length and difficulty of previous units to the length and difficulty of the unit chosen for this study, it is not possible to say at this time that a systematic approach to instruction is better than a "conventional" approach.

2. The materials developed for this unit were effective in helping over 70% of the students attain the desired 70% criterion level on the post-test.

3. The majority of students enjoyed the materials developed for the unit.

4. Because the criterion test contained some items judged to be invalid and others that were unreliable, the criterion test cannot be considered an exact indicator of the degree to which students attained the stated objectives of the unit.

4. DISCUSSION

A systematic approach to instruction is one that, in the opinion of this writer, holds great promise for the improvement of instruction at the classroom level. It is an all-encompassing approach that forces an examination of all aspects of the instructional situation, from the identification of a real need or problem to the evaluation and modification of the program designed to meet the need. Each step in a systems, or systematic, approach lays the groundwork for, and triggers, the next step until all aspects of the instructional process have been examined to the greatest extent possible. Diligent

adherence to a systematic approach will provide an individual or group with a great deal of information on which to base decisions.

Since the human factor is such a large consideration in a systematic approach, materials developed through this process are unlikely to be perfect. The materials used for this study have by no means reached a stage of completion. In fact there is much room for improvement. This study did little more than constitute a field test of the first draft of the materials. They should now be revised and reimplemented.

Perhaps the most serious shortcoming of the instructional design was the attempt to pull everyone along at the same pace. The only opportunity for individual pacing was provided through the student worksheets and games. One of the main reasons that there was not more individualization was the prohibitive cost of providing sufficient materials. Other factors militating against individualization included insufficient equipment such as slide projectors and video tape recorders and inadequate space in which to use them even if they had been available.

Even without complete individualization, the unit could have been made more meaningful to the students. Answer booklets containing solutions to all problems on the worksheets could have been provided. This would have made available to students a means of instant confirmation and would have reduced class time taken for the review of answers. It likely would also have been beneficial to provide the students with more opportunities to discover mathematical relationships for themselves in a laboratory setting or through increased use of physical materials within the classroom setting.

The criterion test is another aspect of the program that has not reached the completion stage. The test used for this study did not completely measure what it was intended to, and there is also some question as to it's reliability. These problems could be rectified by a closer examination of the behavioural objectives during test construction. Questions of doubtful validity and reliability would definitely have to be modified before the program was re-implemented.

5. IMPLICATIONS FOR FURTHER RESEARCH AND DEVELOPMENT

A review of the literature revealed a scarcity of developmental work based on a systems approach. What little work has been done has not been adequately evaluated. What is needed, then, is an expansion of the efforts of those involved in this type of research combined with a more concerted effort towards comprehensive evaluation of their work.

Work of this nature, if it is to be effective, cannot be done by one individual. Even if one individual combined the necessary subject matter competence, knowledge of the systems approach, ability to design and produce materials, and knowledge of testing procedures, he would not have the time to do much developmental work. The systems approach has to be a team approach. The team should be comprised of one or more subject matter specialists, a media specialist, a systems specialist, and an individual with a solid background in tests and measurement. In addition, clerical help is necessary to help produce a variety of printed materials, and production assistants are needed in the production of audiovisual materials.

Projects of this nature should be mounted at a city, county,

or perhaps even provincial level, for it is only at these levels that the materials can reflect the true needs of the target audience. It is questionable if an endeavour such as this can be mounted at the school level as the commitment in terms of dollars and personnel to this type of project may be beyond the capabilities of individual schools.

This should not stop teams of teachers within a school or within a school system from systematically attempting to improve instruction. Teams of this sort, whether acquainted with a systems approach or not, can certainly begin to organize their courses around behavioural objectives. They can begin to seek out alternative ways of presenting materials and perhaps even design and produce some of these materials. They can begin to provide a greater variety of experiences within the classroom and they can attempt to expand their evaluation procedures to include more than just measures of achievement. By using these techniques, even in part, it may be possible that education will begin to be more meaningful and interesting to a larger segment of the student population.

B I B L I O G R A P H Y

BIBLIOGRAPHY

Beckmann, M. W. Teaching the low achiever in mathematics. Mathematics Teacher, 1969, 62(6), 443-446.

Briggs, L.J. Multimedia instruction: A true story. Audiovisual Instruction, 1967, 12(3), 229. (a)

Briggs, L. J. Instructional Media: A Procedure for the Design of Multi-Media Instruction, a Critical Review of Research, and Suggestions for Future Research. Pittsburgh: American Institutes for Research, 1967. (b)

Briggs, L. J. Handbook of Procedures for the Design of Instruction. Pittsburgh: American Institutes for Research, 1970.

Buros, Oscar K. (Ed.) Sixth Mental Measurements Yearbook. Highland Park, New Jersey: The Gryphon Press, 1965.

Bruner, J. S. Toward a Theory of Instruction. Cambridge, Mass.: Belknap Press of Harvard University, 1966.

Campbell, V. N., et al. Water unit. Palo Alto, California: American Institutes for Research, 1964. (Mimeographed). Cited by Leslie J. Briggs, Instructional Media: A Procedure for the Design of Multi-Media Instruction, a Critical Review of Research, and Suggestions for Future Research. Pittsburgh: American Institutes for Research, 1967.

Campbell, D. T., and Stanley, J. C. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally, 1963.

Carpenter, C. R. Approaches to promising areas of research in the field of instructional television. In Wilbur Schramm (Ed.), New Teaching Aids for the American Classroom. The Institute for Communication Research, Stanford, Calif.: Stanford University Press, 1960.

Cronbach, Lee J. Evaluation for course improvement. Teachers College Record, 1963, 64, 67-683.

Curriculum Guide for Mathematics 15-25. Edmonton: Department of Education, 1969.

Davis, Robert B. (Ed.) A Modern Mathematics Program as it Pertains to the Inter-relationship of Mathematical Content, Teaching Methods and Classroom Atmosphere (The Madison Project). Cooperative Research Project No. D-093. Websters Grove, Mo.: Webster College, 1965. (ERIC: ED 003 371).

Davis, Robert B. The next few years. The Arithmetic Teacher, 1966, 13(5), 355-362.

Faris, Gene. Would you believe an instructional developer? Audiovisual Instruction, 1968, 13(9), 971-973.

Ferguson, G. A. Statistical Analysis in Psychology and Education. New York: McGraw Hill, 1966.

Ford Motor Company. Measuring Systems and Their History. Dearborn, Michigan, 1966.

Gagné, R. M. The Conditions of Learning. New York: Holt, Rinehart and Winston, 1965.

Gagné, R. M. Learning theory, educational media and individualized instruction. Educational Broadcasting Review, 1970, 4(3), 49-62.

Geisz, W. H., Sachs, L., and Wendt, R. Modern teaching methods for modern mathematics. National Association of Secondary School Principals Bulletin, 1968, 52(327), 129-140.

General Motors Corporation. Precision, a Measure of Progress. Detroit, Michigan, 1952.

Glaser, R., and Cox, R. C. Criterion-referenced testing for the measurement of educational outcomes. In Robert A. Weisgerber (Ed.) Instructional Process and Media Innovation. Chicago: Rand McNally, 1968.

Herriot, Sarah T. School Mathematics Study Group Report No. 5. The Slow Learner Project: The Secondary School "Slow Learner" in Mathematics. California, Stanford University, 1967. (ERIC: ED 021 755).

Hoffman, Ruth I. The slow learner--changing his view of math. National Association of Secondary School Principals Bulletin, 1968, 52(327), 86-97.

Hooper, Richard. A diagnosis of failure. AV Communication Review. 1969, 17(3), 245-264.

Humphrey, J. H., and Sullivan, D. D. Teaching Slow Learners Through Active Games. Springfield, Illinois: Thomas Books, 1970.

Hurst, R. N., and Postlethwait, S. N. Minicourses at Purdue: an interim report. In J. G. Creager and D. L. Murray (Eds.), The Use of Modules in College Biology Teaching. Washington, D. C., The American Institute of Biological Sciences, 1971.

Johnson, D. A., and Rising, G. R. Guidelines for Teaching Mathematics. Belmont, California: Wadsworth Publishing Co., 1967.

Kemp, Jerrold E. Planning and Producing Audiovisual Materials. Scranton, Pennsylvania: Chandler, 1968.

Kieren, T. E. Activity learning. Review of Educational Research, 1969, 39(4), 509-522.

Kinney, L. B., Ruble, V., and Brown, G. W. General Mathematics, A Problem Solving Approach (Book One). Canada: Holt, Rinehart and Winston, 1969.

Kneitz, M. H., and Creswell, J. L. An action program in mathematics for high school dropouts. Mathematics Teacher, 1969, 62(3), 213-217.

LaFollette, J. J. An Operational Model for Designing Instruction. University of Alberta, 1970. (Mimeographed)

Lehman, H. The systems approach to education. Audiovisual Instruction, 1968, 13(2), 145-148.

Lumsdaine, A. A. Some problems in assessing instructional programs. In Robert Filep (Ed.), Prospectives in Programming. New York: MacMillan, 1963.

Mager, Robert F. Preparing Instructional Objectives. Palo Alto, California: Fearon, 1962.

McDonald, R. L., and Dodge, R. A. Audio-tutorial packages at Columbia Junior College. In J. G. Creager and D. L. Murray (Eds.), The Use of Modules in College Biology Teaching. Washington, D. C., The American Institute of Biological Sciences, 1971.

Miller, Donald M., and others. Multi Media Instructional Programs in Mathematics--Demonstration and Experimentation. The Assimilation of New Media in the Instructional Program of a Rural School. Final Report. Project No. OE-7-59-9001-274. Wisconsin: Wisconsin Heights School District, 1966. (ERIC: ED 028 637).

Murray, D. L. The components of a module. In J. G. Creager and D. L. Murray (Eds.), The Use of Modules in College Biology Teaching. Washington, D. C., The American Institute of Biological Sciences, 1971.

Philips, H. L. Why we are concerned about low achievers in mathematics. In Lauren Woodby (Ed.), The Low Achiever in Mathematics. Washington, D. C., United States Government Printing Office, 1965.

Postlethwait, S. N., Novak, J., and Murray, H. T. Jr. The Audio-Tutorial Approach to Learning. Minneapolis, Minn.: Burgess, 1969.

Postlethwait, S. N., and Russell, J. D. "Minicourses"--The style of the future? In J. G. Creager and D. L. Murray (Eds.), The Use of Modules in College Biology Teaching. Washington, D. C., The American Institute of Biological Sciences, 1971.

Remple, T. Personal interview. June, 1971.

Research for Better Schools, Inc. Individually Prescribed Instruction. Philadelphia, Pennsylvania, n.d.

Rogler, Paul V. A Proposal for the Development of Materials of Instruction for a General Mathematics Curriculum in Grade Nine. Project No. 6-8786. Delaware: Wilmington Public Schools, 1967. (ERIC: ED 028 256).

Romberg, T. A. Current research in mathematics education. Review of Educational Research, 1969, 39(4), 473-492.

Rosenbloom, Paul C. Implications of psychological research. In Lauren Woodby (Ed.), The Low Achiever in Mathematics. Washington, D. C., United States Government Printing Office, 1965.

Shah, Sair Ali. Selected geometric concepts taught to children ages seven to eleven. Arithmetic Teacher, 1969, 16(2), 119-128.

Shea, E. A. The graphic arts center in a public school system. Audiovisual Instruction, 1968, 13(4), 356-363.

Shoemaker, Terry. Cited by R. I. Hoffman. The slow learner--changing his view of math. National Association of Secondary School Principals Bulletin, 1968, 52(327), 86-97.

Stewart, D. K. A learning-systems concept as applied to courses in education and training. In Raymond V. Wiman and Wesley C. Meierhenry (Eds.), Educational Media: Theory Into Practice. Columbus, Ohio: Charles E. Merrill Publishing Co., 1969.

Stowe, R. A. (Ed.) Case Studies in Instructional Development, Bloomington, Indiana: Instructional Development Department, Audio-Visual Center, Indiana University, 1969. (Mimeographed).

Westrom, M. L. Individualized Instruction in Grade Seven Mathematics: Rationale, Description, and Feasibility Report. Unpublished masters thesis, University of Alberta, 1971.

White Paper on Metric Conversion in Canada. Ottawa: Queens Printer for Canada, 1970.

Woodby, Lauren. (Ed.) The Low Achiever in Mathematics. Washington, D. C., United States Government Printing Office, 1965.

Zimmerman, Joseph T. Low Achiever Motivational Project. Iowa: Des Moines Public Schools, 1968. (ERIC: ED 025 433).

APPENDIX A

COMMENTS MADE BY THE COOPERATING TEACHER

APPENDIX A

COMMENTS MADE BY THE COOPERATING TEACHER

My overall positive impression of the audio-visual method, supports the fact that more educators should try this new innovative approach to teaching mathematics to the less-interested student. I'm amazed at the amount of work that was put into the preparation of slides, tapes, lesson plans and question sheets. This provided the necessary motivation for these students. The multi-media approach provided a more relaxed atmosphere at which time an instructor could introduce the "dry" factual information but worthwhile information in a more productive manner.

As I have already suggested, the number of advantages to this approach surpass the number of disadvantages. Structured learning proved to be very productive as demonstrated in the student's involvement. This relieved the teacher from some of his daily planning and offered more of his time to the problems of the individual student. The inclusion of a teacher's guide with the unit eliminated any problems for me, a guide that provided the necessary information to make this approach workable. I'm confident that the multi-media method is superior to the traditional textbook approach, producing an atmosphere which is more conducive to learning.

To include a realistic evaluation of the total approach, one must consider some disadvantages with the realization that the approach is in its experimental stage. I thought the approach warranted a longer instructional period to allow for more work to be done in class

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at the guidance of the teacher. The time factor of setting the equipment up and taking it down before and after class would be tremendously difficult for one teacher to handle. At the same time, the lack of availability of equipment at a particular school would certainly affect the continuance of this approach. This however, would force the school and school board to consider the importance of a teacher's aide and the importance of having sufficient types of equipment available.

It is also realized that the material could be used again and again as the unit reappears each year with few variations. Nevertheless, I would find it very difficult to expand this approach to include every unit in the Mathematics 15 curriculum. It would take an enormous amount of time to prepare material in this multi approach, and at the same time make up lesson plans for each day.

Commercially, there are a number of ways one can combat this problem. A "unit-pack" will blossom and prove to be a more productive method of relating information to the less motivated individual. I am sure that the tests and questionnaires given at the end of this unit certainly reinforce the idea that the multi-media approach was a more effective and successful way of teaching a unit in measurement.

APPENDIX B

AIMS AND OBJECTIVES

APPENDIX B

AIMS AND OBJECTIVES

I. Aims

The specific aims of this unit are to assist each learner in:

- developing an interest in measurement through a look at the history of measurement and practical applications of measurement.
- becoming aware of the fact that units of measure are often arbitrarily established and that all measurement is approximate.
- developing facility in using metric units and in converting from English to metric units and vice versa. Problems will be given involving conversions in linear, volume, and weight measurements.

II. Objectives

1. The student must be able to write, in his own words, a correct definition of measuring.
2. The student should, in his own words and in a limited period of time, be able to explain why an answer obtained through measuring is always approximate.
3. The student, when presented with a series of numbers including both measurements and counts, will be able to correctly indicate which of the numbers are approximate and which are exact.
4. Students will be able to correctly measure lengths of lines and report results to different degrees of accuracy.
5. Students will be able to correctly "round" numbers representing measurements to different degrees of accuracy. In questions where it is applicable, a ruler may be used.
6. Students will be able to correctly define the terms millimeter, centimeter, decimeter, and kilometer in terms of a meter.
7. Students will be able to correctly convert simple linear measurements from one metric unit to another using a metric ruler if necessary.

8. The student, when provided with a table of commonly used English and metric equivalents, will be able to correctly solve problems involving conversion of lengths from one set of units to the other.

9. The student will be able to correctly answer the following questions.
-How many fluid ounces in a cup?
-How many cups in a quart?
-How many fluid ounces in a quart?
-How many pints in a quart?
-How many quarts in a gallon?
-How many ounces in a gallon?

10. The student will be able to correctly define the terms milliliter, centiliter, deciliter, and kiloliter, in terms of a liter. The answers may be written as decimals or as fractions.

11. Students, when provided with a table of commonly used English and metric equivalents will be able to correctly solve problems involving conversion from one set of units to the other.

12. The student should know that 1 c.c. of water weighs one gram and demonstrate this knowledge by solving problems which require the determination of the weight, in grams of certain water filled containers.

13. The student must be able to correctly define the terms milligram, centigram, decigram, and kilogram, in terms of a gram. The answers may be written as decimals or fractions.

14. The student, when provided with a table of commonly used English and metric equivalents, will be able to correctly solve problems involving conversion of weights from one set of units to the other.

APPENDIX C

STUDENT OBJECTIVE SHEET

APPENDIX C

STUDENT OBJECTIVE SHEET

Listed below are the things you will be learning in the next two week period. If you take care to learn all of the items you should do very well on the test to be given at the end of the unit.

1. You must be able to write, in your own words, a definition of measuring.

2. You must be able to explain, in a short sentence, why measuring is always approximate.

3. You must be able to distinguish between numbers that represent approximate numbers (measurements) and those that represent exact numbers (counts).

4. You must be able to correctly measure lengths of lines and round these measurements to different degrees of accuracy.

5. You must also be able to round numbers representing measurements to different degrees of accuracy.

6. You should be able to correctly define the following terms.

   millimeter, centimeter, decimeter and kilometer in terms of a meter. (eg. 1 mm. = 1/1000 of a meter)

   milliliter, centiliter, deciliter and kiloliter in terms of a liter.

   milligram, centigram, decigram and kilogram in terms of a gram.

7. When provided with a table of conversions you should be able to correctly solve problems requiring conversion from metric units to English and vice versa.

   eg. If you walked for 40 meters, how far would that be in yards? (1 meter = 1.09 yards.)

8. You should be familiar with various units of measure within the English system such as pounds, ounces, cups, quarts, gallons, etc. You should know some of the basic relationships between these units such as 16 ounces = 1 lb.

9. You should be able to convert both English and metric units from one type of unit to another type of unit within the same system.

eg. 3.6 meters = ________cm. (Answer 360 cm.)

36 inches = ________ft. (Answer 3 ft.)

For questions of this type see Lesson #4 question 13.

10. You should know that 1 gal. of water weighs 10 lbs. at $39^{o}F$. and that 1 c.c. (ml.) of water weighs 1 gram. You should be able to apply this knowledge in solving questions like #2 on worksheet 7 and question #3 on worksheet 9.

APPENDIX D

TEST USED AS A PRE-TEST

AND AS A POST OR CRITERION TEST

APPENDIX D

MEASUREMENT TEST

Name______________________________ Period__________________________

1. Write, in your own words, a definition of measuring.

2. The earliest measuring unit known to man was called the __________. It was approximately ________ inches long but varied from person to person.

3. Explain briefly why a number obtained by measuring (weight, length, etc.) is always approximate.

4. The numbers below represent measurements and counts. Indicate which of the numbers are approximate and which are exact by writing an A for approximate or E for exact beside the numbers.

   23 yardsticks

   3/4 of a gallon

   3 ft.

   50% of 60 people

   $2.65

   145 lbs.

5. Explain briefly what was wrong with the earliest forms of measurement.

6. Measure this line. What is its length when rounded to the nearest foot. ____

7. Measure this line and round your measurement to the required degree of accuracy. A ruler may be used to aid you in rounding.

   ____

   Rounded to the nearest inch ________

Rounded to the nearest half inch ________

Rounded to the nearest quarter inch ________

8. Round the number 3246.4783 to the nearest thousandth ____________

to the nearest hundredth ____________

to the nearest tenth ____________

to the nearest one ____________

to the nearest ten ____________

to the nearest hundred ____________

to the nearest thousand ____________

9. Define the following in terms of a meter.

a) 1 cm. = _______ meter   c) 1 mm. = _______ meter

b) 1 km. = _______ meter   d) 1 dm. = _______ meter

10. Define 1 nickel in terms of a dollar.

11. Define 1 foot in terms of a yard.

12. The following questions may be done with the aid of a ruler if so desired.

a) 29 mms. = ______cm.   d) 9.6 cm. = ______mm.

b) 1.4 meters = ______cm.   e) 46 cm. = ______meters.

c) 2 kms. = ______meters.

13. Define a meter as was originally defined by French scientists.

14. How much would a gallon and a half of water weigh if the temperature of the water was 39 ^{o} F?

15. How many fluid ounces in a quart?

16. Define the following in terms of a liter.

a) 1 milliliter = b) 1 centiliter =

b) 1 deciliter = d) 1 kiloliter =

17. A liter is made up of __________mls., or ______cls., or _____dls.

18. Complete:

1 _______ = 1/1000 of a g.

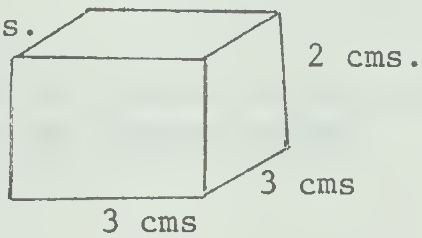
1 _______ = 1000 g.

1 _______ = 1/10 of a g.

1 _______ = 1/100 of a g.

_______ = 1 g.

19. How much does the container you see below weigh? Presume that it is filled with water and that the sides of the container are weightless.



This table of conversions will be needed for the remaining questions.

1 mile = 1.61 kms.	1 gal. = 4.5 liters	1 lb. = 0.453 kg.
1 km. = .62 miles	1 liter = .22 gals.	1 kg. = 2.2 lbs.
1 m. = 1.09 yards	1 quart = 1.14 liters	

20. A car travels at a speed of 55 m.p.h. How fast would this be in k.p.h. (kilometers per hour). Round your answer to the nearest km.

21. Bob runs the 100 yard dash while Frank runs the 100 meter dash. Which one runs farthest? __________. How much further does he run? __________(Answer in yards or meters).

22. A man purchases 32 liters of gasoline. How many gallons is this? Round your answer to the nearest gallon.

23. A housewife purchases 6 quarts of milk. How many liters is this?

24. A girl weighs 102 lbs. How much does she weigh in kg? Round your answer to the nearest kg.

25. A weightlifter lifts 120 kg. What is this in pounds? Round your answer to the nearest pound.

26. If gasoline sells for 23¢ a liter in France, this is how much per gallon? Round your answer to the nearest cent.

APPENDIX E

SAMPLE LESSON INCLUDING

Teacher's Guide

Lesson Plan showing the analysis of objectives

Slide-Tape Script

Worksheets

APPENDIX E

Teachers guide to Lesson #4.

1. Direct students to objective 6.

2. Show slide tape presentation on the history of the metric system.

3. Assign question 1 on worksheet . . . Define an inch.
   Check answer. Point up the variety of ways which it can be defined.

4. Assign question 2 and 3. Review answers.

5. Have students take out metric rules or distribute meter sticks.
   Have them name the smaller units on the stick.

   Show them what a decimeter is and review abbreviations mm., cm., dm., m.

6. Assign question 5-10. Meter sticks may be used if desired.
   Check answers.

7. Assign question 11. While checking answers, introduce the meaning of the terms centi, milli, deci, kilo.

8. Assign question 12. Check answers.

9. Assign questions 13 and 14. Check if time.

APPENDIX E

Lesson #4

Objectives

1. Students will be able to correctly define the terms millimeter, centimeter, decimeter, and kilometer in terms of a meter.

2. Students will be able to correctly convert simple linear measurements from one metric unit to another using a metric ruler if necessary.

Media

Slide tape presentation, teacher demonstration, student activity involving manipulation of rulers and work on worksheet.

Modes

Large group presentation followed by individual work.

Alternatives

Introductory slide-tape followed by individual audio-tutorial combined with worksheets or programmed instructional sheets.

Analysis of objective 1

Principles to be learned: Define millimeter, centimeter, decimeter, and kilometer in terms of a meter.

INSTRUCTIONAL EVENT	MEDIUM
Gain attention	Slide-tape set reviews history of linear measuring units. Describes briefly the origin of the metric system and some of the basic measuring units.
Inform learner of expected performance	Refer students to objective 6 on Student Objective Sheet.

INSTRUCTIONAL EVENT	MEDIUM
Review component concepts	The concepts of millimeter, centimeter, decimeter, and meter are reviewed by examining meter sticks or metric rulers. The concept of a kilometer is introduced.
Present verbal and visual cues to stimulate learning	Direct students to questions 1-4 on the worksheet. These questions provide practice in defining one unit in terms of another. After answers are reviewed, direct students to questions 5-11 on worksheet. Question 11 is duplicated on a transparency. Review all of the questions with students stressing the definitions of the metric units.
Appraisal	Assign and review questions 14-22 on worksheet.

Analysis of objective 2

Problem to be solved: Convert simple linear measurements from one metric unit to another using a metric ruler if necessary.

INSTRUCTIONAL EVENT	MEDIUM
Inform learner of expected performance	Teacher informs students that they will be required to do simple conversions.
Review component concepts and principles	Relationships between the various metric units are reviewed.
Present verbal and visual cues to stimulate learning	Conversion problems are demonstrated by the teacher. Stress is put on the point that conversions can be made in the metric system simply by shifting the decimal point. Students are permitted to do all conversions with the aid of a ruler.
Appraisal	Assign question 13 on worksheet. Review answers.

APPENDIX E

Lesson #4 Slide-Tape script (Page one).

MEASUREMENT	When we began this unit several days ago we looked at the history of measurement. Of course we looked at only a portion of the history--we left it quite incomplete. Today we are going to look at another chapter in the history of measurement . . . . the origin of the metric system.
ENGLISH AND METRIC SYSTEM	*There are two basic systems of measurement--the English and the metric. The one that we've been working with for the past few days and the one we commonly use in day to day life is the English system. The English system uses terms such as these.
TERMS	*Inch, Foot, Quart, Yard, Mile, Pint, Gallon, Pound . . .
SCIENTISTS	*The development of the English system wasn't too scientific. Scientists didn't sit down in a lab and discover the inch.
BLANK	*Do you remember the origin of the inch?
THUMB ON RULER	*Right! The thumb was used as the basic unit for dividing the foot into 12 equal parts. Each part was called an uncia, meaning 1/12th. Today we

(Page 2 of slide-tape script)

	call this unit the inch.
BLANK	*How about the foot?
FOREARM AND FOOT	*Again, this unit was based on a body measurement. Remember, a foot was originally decided to be 2/3 of a cubit.
FOREARM AND RULER	*A cubit was the length of a forearm and was approximately 18 inches in length. 2/3 of 18 inches is 12 inches. This 12 inches also happened to be very close to the measurement of an average man's foot. Thus, the name foot.
BLANK	*Can you remember the origin of the mile?
ROMAN SOLDIERS	*Remember the Roman soldiers as they marched across the world. Every 1000 paces they placed a mile marker. Each pace was approximately 5 ft. and, therefore, the distance they covered was very close to our present day mile. They would cover approximately 5000 feet compared to our present 5,280. By the way isn't 5280 a convenient number?
KETTLE	*Speaking of convenient numbers, how about our temperature measurements. Why does water boil
ICE CUBES	at 212 degrees F.? *Why does it freeze at 32 degrees F.?

[illegible]

[illegible]

[illegible] [illegible]

[illegible] [illegible]

[illegible]

[illegible]

[illegible] [illegible]

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[illegible] [illegible]

[illegible]

[illegible] [illegible]

[illegible]

(Page 3 of slide-tape script)

BLANK	*Well, we have our measuring systems. They're not too convenient but we're used to them. For today they're fine but what about tomorrow? (pause)
YOUNG GIRL	*Here she is. Miss Playground 1971. And what measurements...45....50.....50.....centimeters that is.
BOY ON BIKE	*"Hey, what a fast bike. I bet she'll do 60 easy!"
BLANK	*Well maybe 60 k.p.h. Hmmm. Centimeters and kilometers yet. You might hear this sort of thing in Europe. In Canada? Well, it could be pretty soon. The Canadian Government has decided that the Metric system will one day be adopted by Canadians whether they like it or not.
QUESTION	*Why the metric system? Is it any better? Let's look at the history of it.
BLANK	*The metric system, as we know it, got it's start around 200 years ago--180 to be more precise. In fact, the year was 1790.
NAPOLEON	*Napoleon Bonaparte was just beginning to come to power in France.

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FRENCH SCIENTISTS	*French scientists had begun work on a new and more precise standard of measurement. Instead of basing their measuring system on body measurements, they wanted to base it on something more permanent. Their answer.....
EARTH	*The Earth.
MEASURING THE EARTH	*They drew an imaginary line from the north pole, through Paris (naturally) to the equator. This distance they felt, would never change. They then divided this distance into 10,000,000 parts. Each part was called a
METER	*meter.
METRIC SYSTEM	*Thus, the metric system came into being. Not without its problems mind you, for the French population already had it's own measuring systems and felt no happier about having to use the metric system than we do when we think about having to use it. However, gradually it was adopted by France and most of Europe. Today, Canada and the U.S. are two of the very few remaining countries on the English system.

(Running Time--5:25)

APPENDIX E

Lesson #4 Worksheet 1

1. Define an inch.

2. Define a foot in terms of a yard.

3. Define one foot in terms of a mile.

4. Write the names of the smaller units found on a meter stick.

Questions 5-10 may be answered with the aid of a meter stick if desired.

5. Define mm. in terms of a cm.

6. Define mm. in terms of a dm.

7. Define mm. in terms of a meter.

8. Define cm. in terms of a dm.

9. Define cm. in terms of a meter.

10. Define dm. in terms of a meter.

11. Fill in the chart.

1 cent =	dollar	1 mm. =	meter
1 dime =	dollar	1 cm. =	meter
1 dollar =	dollar	1 dm. =	meter
1 grand =	dollars	1 m. =	meter
		1 km. =	meters

12. Convert all answers in question 11 to decimal notation.

13. Question 13 may be done with the aid of a meter stick if so desired.

    a) 13.7 cms. = _______ mm.

Lesson #4 Worksheet 2

Question 13 continued.

b) 27 mm. = _______ cm.

c) 2.5 m. = _______ cm.

d) 65 cm. = _______ m.

e) 3.5 kms. = _______ m.

f) 205 mm. = _______ cm.

g) 96 cm. = _______ mm.

h) 1.8 m. = _______ cm.

i) 37 cm. = _______ m.

j) 4 dm. = _______ cm.

14. Define 1 mm. in terms of a meter.

15. Define 1 cm. in terms of a meter.

16. Define 1 km. in terms of a meter.

17. Define 1 mm. in terms of a cm.

18. Define 1 dm. in terms of a m.

19. Define 1 inch in terms of a foot.

20. Define 1 inch in terms of a yard.

21. Define 1 foot in terms of a mile.

22. Define a meter as was originally defined by French scientists.

APPENDIX F

RULES FOR THE MILES-KILOMETERS

AND

LITERS-GALLONS CONVERSION GAMES

AND

A GAME "BOARD"

APPENDIX F

MILES-KILOMETERS CONVERSION GAME

GOING FROM A TO B.

1. In his turn, each player shakes two dice. The total on the dice indicates the number of kms. that a player may advance. THIS TOTAL MUST BE CONVERTED FROM KMS. TO MILES BEFORE THE PLAYER ADVANCES.

2. When converting kms. to miles, it will always be necessary to "round" an answer to the nearest whole number.
eg. 6 kms. $\approx$ 3.72 miles (Round 3.72 to 4).

3. When a player lands on a numbered square he must consult the code in the rules for instructions on his next move. For example, landing on a square numbered 1 means that, on this next turn, the player will double the throw on the dice.

4. Blue squares indicate service stations. When a player lands on a service station he must miss one turn for refuelling.

5. A player landing on a square already occupied by another player must return to the starting point.

6. Terminals A and B cannot be entered unless a player shakes a score exactly equal to the number of remaining miles or kms. to the terminal.

GOING FROM B TO A.

1. In his turn, each player shakes only one die. The score indicates the number of miles that a player may advance. THIS TOTAL MUST BE CONVERTED FROM MILES TO KMS. BEFORE THE PLAYER ADVANCES. Again, all answers must be rounded.

2. All other rules are similar to the rules for the first part of game.

CODE

1. Double speed by multiplying the score on the next throw by two.
2. Reduce speed by dividing the score on the next throw by two.
3. Multiply the two scores on the dice. Multiply this answer by 100. This is your score in METERS. Convert and round this answer to the nearest kilometer. Then convert this number to miles.

Miles-Kilometers Conversion Game

Code Continued

4. Do not convert. Instead, move a number of squares equal to the score on the dice.
5. Miss one turn while buying park sticker.
6. Caught in a speed trap. Miss one turn.
7. Scenic view. Stop and look. Miss one turn.
8. Take the side trip.
9. Forgot lunch. Return to A. Better luck next time.
10. Too bad! Flat tire. Miss one turn.
11. Return to 7 for another look at the view. Do not miss a turn.
12. Hungry. Stop for supper. Miss one turn.

APPENDIX F

LITERS GALLONS GAME

Object--To travel from A to B and back without running out of gasoline.

FROM A TO B.

1. In his turn, each player shakes two dice. The scores on the dice are multiplied. This product gives the number of liters of gasoline that a player is provided with for making it to the next service station. The number of liters must be converted to gallons and rounded to the nearest gallon.

2. Each square represents 20 miles. Each car goes 20 miles to a gallon. Therefore, once a player has determined how many gallons of gas he has, he will be able to determine how many squares he may move.

3. Each player is given two refills (shakes) to reach any service station he chooses. If he does not reach a service station in two throws, he must be towed in. He misses one turn for each square that he must move to reach a station.

4. Upon reaching a station a player is automatically given another two shakes. He does not stop or miss a turn upon reaching a station.

5. A player may use his turn for travelling forward or backward to avoid being stranded on the road.

6. Optional rule: If you wish, you may require a player to state the direction in which he intends to move before he shakes the dice.

FROM B TO A

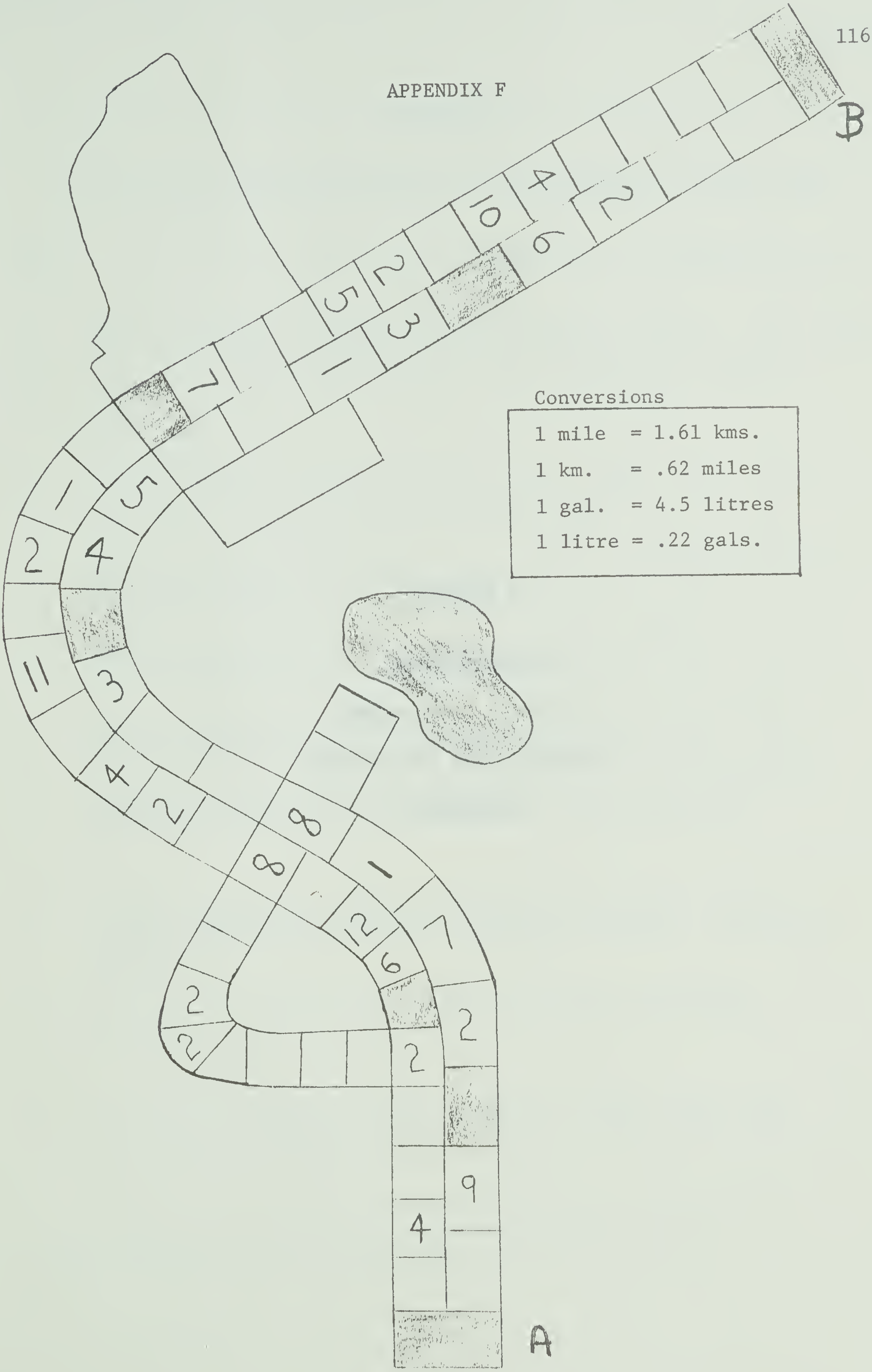
1. In his turn, each player shakes two dice. The scores on the dice are added. This sum gives the number of gallons of gasoline that he is provided with for making it to the next service station. The number of gallons must be converted to LITERS and rounded to the nearest liter.

2. Each square represents 20 kms. Each car goes 4 kms. to a liter. Therefore, once a player has determined how many liters of gas he has, he will be able to determine how many squares he may

move. (HINT: 5 liters of gas are required to move one complete square).

3. All other rules are the same as going from A to B.

APPENDIX F



Conversions

1 mile	= 1.61 kms.
1 km.	= .62 miles
1 gal.	= 4.5 litres
1 litre	= .22 gals.

APPENDIX G

QUESTIONNAIRES

ADMINISTERED PRIOR TO,

AND AT THE CONCLUSION OF,

THE STUDY

APPENDIX G

QUESTIONNAIRE ADMINISTERED PRIOR TO THE COMMENCEMENT OF THE STUDY

Name________________________________ Class__________ Period__________

1. Did you like math when you were in elementary school? yes __ no __

2. Did you do well in math when you were in elementary school?

   yes __ no __

3. Did you like math when you were in junior high? yes __ no __

4. What was your final mark in grade nine math? ______________

5. Have you ever taken math 10? yes __ no __ . If yes, what was your final mark? __________

6. Are you taking Math 15 only because you are required to take a math course if you want a high school diploma? yes __ no __

7. Are you taking Math 15 because you want to raise your marks high enough to get into the academic program? yes __ no __

8. If you are taking Math 15 for reasons other than suggested in questions 6 and 7 please indicate what your reasons are.

9. Are you planning on taking any other math classes? If yes, please indicate which of the following. Math 10 __ Math 13 __ Math 25 __

10. What have you liked about the Math 15 course this year?

11. What have you disliked about the Math 15 course this year?

12. What would you do to make Math 15 more interesting?

13. What do you intend on doing after you finish high school?

APPENDIX G

QUESTIONNAIRE ADMINISTERED AT THE CONCLUSION OF THE STUDY

Name______________________________ Class__________Period_______

1. Did you like math when you were in elementary school? yes __ no __

2. Did you like math when you were in junior high? yes __ no __

3. Indicate which statement best describes your attitude towards the slide-tape sets and video tapes.

   a) I didn't like them at all. __   c) I liked them. __

   b) I didn't like them much. __   d) I liked them very much. __

   Use the remaining space for comments about the slides or video tapes.

4. Indicate which statement best describes your attitude towards the two games (miles-km. and liters-gallons conversion games).

   a) I didn't like them at all. __   c) I liked them. __

   b) I didn't like them much. __   d) I liked them very much. __

   Use the remaining space for comments about the games.

5. Indicate which statement best describes your attitude towards the worksheets.

   a) I didn't like them at all. __   c) I liked them. __

   b) I didn't like them much. __   d) I liked them very much. __

   Use the remaining space for comments about the worksheets.

6. Indicate which statement best describes how helpful the "objective sheets" were to you in preparing for the final test.

   a) They were no help at all. ___ c) They were helpful. ___

   b) They were not much help. ___ d) They were very helpful. ___

   Use the remaining space for comments on the "objective" sheets.

7. What else did you like about the unit on measurement?

8. What else did you dislike about the unit on measurement?

9. What would you do to make the unit more interesting?

10. What would you do to make Math 15 more interesting?

Any more comments about anything?